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ELECTRON/PROTON SPECTROMETER
CERTIFICATION DOCUMENTATION
ANALYSES

Document Number EPS-779

(NASA-CR-128705) ELECTRON/PROTON
SPECTROMETER CERTIFICATION DOCUMENTATION
ANALYSES (Lockheed Electronics Co.)
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this document may be better
studied on microfiche

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Houston, Texas

Under Contract NAS 9-11373

for

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

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ELECTRON/PROTON SPECTROMETER
CERTIFICATION DOCUMENTATION
ANALYSES

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ELECTRON/PROTON SPECTROMETER
CERTIFICATION DOCUMENTATION:
ANALYSES

1.0 INTRODUCTION

This document contains a compilation of analyses generated throughout the progressive development of the Electron/Proton Spectrometer (EPS) for Skylab. The purpose of the compilation of these data is to document the analyses required by the "EPS Verification Plan" (LEC Document No. EPS-435). The "EPS Verification Plan" was generated to satisfy the "Apollo Applications Program Ancillary Hardware General Requirements" (MSC Document No. MSC-KA-D-69-44, Revision A), and the NASA Contract, "Electron/Proton Spectrometer for Skylab", NAS 9-11373.

2.0 CERTIFICATION OF THE EPS

The certification of the EPS requires that the various tests, inspections, and analyses be documented and approved/accepted by the cognizant Reliability and Quality Assurance personnel for the EPS program. The certification is to be accomplished in three parts in accordance with the "EPS Verification Plan".

- Evaluation and review of the "Qualification Test Procedure", the records of the qualification testing of the EPS Qualification Test Unit, the "Qualification Test Report", and the acceptance test procedures.
- Evaluation and review of the inspection procedures and data points defined by the "EPS Verification Plan", and the results of the various inspections.

2.0 Continued

- Evaluation and review of the various analyses performed during the development and testing of the EPS.

2.1 Qualification Verification

The "Qualification Test Procedure", the records of the qualification testing of the EPS Qualification Test Unit, the "Qualification Test Report", and the acceptance test procedures have been reviewed and accepted by NASA/MSD.

2.2 Inspection Verification

The inspection procedures and data points, as defined by the "EPS Verification Plan", and the results of the various inspections have been reviewed and accepted by NASA/MSD.

2.3 Analyses Verification

The collection and identification of the various analyses performed during the development of the EPS are contained within this document to facilitate their evaluation and review. Analyses made during the early development stages of the EPS program are not necessarily correct for the final item. The early analyses, however, provided the basis for arriving at the final configuration of the EPS, and reflect the progression of scientific and engineering skills in the development of a superior product.

3.0 VERIFICATION MATRIX

The "Verification Matrix", a sub-section of the "EPS Verification Plan", provides, in matrix form, a listing of the various EPS functions to test, inspect, and analyze, in order to comply with the requirements of the EPS contract NAS 9-11373

3.0 Continued

and the "AAP Ancillary Hardware General Requirements". The contents of this document, therefore, is a representative cross-section of the various analyses made during the development of the EPS, and are arranged in section order as found in the "Verification Matrix" (see Table 1 - "EPS Verification Plan - Verification Matrix").

TABLE I - EPS VERIFICATION PLAN - VERIFICATION MATRIX

VERIFICATION METHOD:

1. TEST
2. ASSESSMENT
 - A. SIMILARITY
 - B. ANALYSIS
 - C. INSPECTION
 - D. DEMONSTRATION

TEST TYPE

- NR - NO REQUIREMENT
- A - DEVELOPMENT
- B - QUALIFICATION
- C - ACCEPTANCE
- D - PRE-INSTALLATION
- E - INTEGRATED SYSTEMS
- F - PRELAUNCH
- G - OTHER

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.0	X								
3.1	X								
3.1.1	X								
3.1.1.1	X								
3.1.1.1A		1							2.3.4
3.1.1.1B		1							2.3.4
3.1.1.1C		1							2.3.4
3.1.1.1D		1							2.3.4
3.1.1.1E			1						3.1
3.1.1.1F		1							2.3.4
3.1.1.1G									
3.1.1.2	X								
3.1.1.2.1		1	1						2.1 & 3.1
3.1.1.2.2		1	1	1					2.3.4, 3.1.8 & 4.2
3.1.2	X								

TABLE I - EPS VERIFICATION PLAN - VERIFICATION
MATRIX (Continued)

EPS-435

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.1.2.2	X								
3.1.2.2.1	X								
3.1.2.2.1a		2C							
3.1.2.2.1b		2C							
3.1.2.2.1d		2C							
3.1.2.3		2B							
3.1.2.4			1						3.1.2 thru 3.1.7
3.1.2.5			1						3.1.2 thru 3.1.7
3.1.2.6			1						3.1.2 & 3.1.3
3.1.2.7			2C						
3.1.2.8		2B							
3.2	X								
3.2.1	X								
3.2.1.1	X								
3.2.1.1.1			2B						
3.2.1.1.2			2B						
3.2.1.1.4			2B						
3.2.1.1.5	X								
3.2.1.1.6			1						3.1.6
3.2.1.5	X								
3.2.1.5C		2B							
3.2.1.6	X								
3.3	X								
3.3.1	X								
3.3.1.6			2C						
3.3.1.7	X								
3.3.1.7.1			2B						
3.3.1.8	X								
3.3.2	X								

TABLE I - EPS VERIFICATION PLAN - VERIFICATION
MATRIX (Continued)

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.3.2.3			2C						
3.3.2.4		2B	2B						
3.3.2.5			2C						
3.3.2.6		2B	2B						
3.3.2.7		2B	2B						
3.3.2.9		2B	2B						
3.3.2.10		1	1						2.3.3 & 3.1.6
3.3.2.11			1						3.1.2
3.3.2.12	X								
3.3.2.13			1	1					3.1.8 & 4.2
3.3.2.14		1	1						2.3.3 & 3.1.6
3.3.2.15				2C					
3.3.2.16				2C					
3.3.4	X								
3.3.4a			2B						
3.3.4b			2B						
3.3.4d			2B						
3.3.5			2C	2C					
3.3.6	X								
3.3.6.1		2B	2C						
3.3.6.2		2B	2D	2D					
3.3.7		2B	2B						
3.3.8	X								
3.3.8.1	X								
3.3.8.2	X								
3.3.9		2B	2B						
3.3.10	X								

TABLE I - EPS VERIFICATION PLAN - VERIFICATION
MATRIX (Concluded)

Section 3.0 End Item Specification Reference	VERIFICATION METHOD								Verification Plan Reference
	NR	A	B	C	D	E	F	G	
3.3.10.1	X								
3.3.10.2		2B	2B						
3.3.10.3		2B	2C	2C					
3.3.10.4		2B	2C	2C					
3.3.10.5			2C	2C					
3.3.10.6			2C	2C					
3.3.10.7		2B	2C	2C					
3.3.10.8				2C					
3.3.10.9		2B	2B						
3.3.10.9.1		2B	2B						
3.3.11		2B	2B						
3.3.12		2B	2B						
3.3.13		2B	2C						
3.3.14		2B	2C						
3.3.15		2C	2C	2C					
3.3.16		1	1						2.3.1 & 3.1.7
3.3.17		2C	2C	2C					
3.3.18			2B						
3.3.19	X								

VERIFICATION MATRIX'S SECTIONS
APPLICABLE TO ASSESSMENT ANALYSIS
(INDEX)

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3.1.2.3 Minimum Useful Life

The detectors are the only items on the EPS having a limited life expectancy. The detectors, therefore, are subjected to a special screen and burn-in program to determine their operating parameters, their statistical useful life, and their reliability. Also, because of the limited life expectancy of the detectors, the EPS flight units will be delivered to NASA/MSD with diodes mounted in place of detectors. The flight detectors will be installed on the EPS flight units shortly before launch.

3.1.2.8 Safety

The document "Safety Assessment for EPS Electron-Proton Spectrometer", EPS-425, included herein, presents the safety analyses.

SAFETY ASSESSMENT
FOR
EPS ELECTRON-PROTON SPECTROMETER

LEC Document Number EPS-425

Prepared by
Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas
August 1971

SAFETY ASSESSMENT
FOR
EPS ELECTRON-PROTON SPECTROMETER

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SAFETY ASSESSMENT

1. PURPOSE

The purpose of this safety analysis is to identify the efforts required to assure relatively hazard free operation of the EPS and to meet the safety requirements of the program.

Safety engineering criteria, principles, and techniques in applicable disciplines is stressed in the performance of system and subsystem studies; in test planning, and in the design, development, test, evaluation, and checkout of the equipment, and the operating procedures for the EPS program.

2. DATA

There are no formal data submittal requirements specifically associated with the EPS system safety engineering program listed in the contract. However, letter reports and safety assessment requiring the attention of NASA/MSD will be transmitted when appropriate and any accident/incident reports prepared in response to NASA/MSD direction will be submitted.

3. SYSTEM SAFETY ASSESSMENT

3.1 TOXIC FLUIDS OR MATERIALS

No toxic fluids or materials will be used during the processes of manufacturing, testing, or handling of the EPS.

3.2 FLAMMABLE FLUIDS AND MATERIALS

No flammable fluids or material will be used in the manufacturing, testing, or handling processes of the EPS, except isopropyl alcohol for cleaning the electronic subassemblies.

3.3 NUCLEAR COMPONENTS/RADIATION

The EPS instrument itself does not contain any nuclear components; however, the laboratory equipment will contain radiation sources. LEC has been licensed to use radioactive sources.

3.4 RADIOACTIVE SOURCES

<u>Radioactive Material</u>		<u>Quantity</u>
Barium-133*	Solid, Elemental	2 sources not to exceed 100 microcuries each
Cesium-137*	Solid, Elemental	4 sources, each of three not to exceed 100 microcuries, one not to exceed 1 microcurie
Bismuth-207*	Solid, Elemental	4 sources, each of three not to exceed 100 microcuries, one not to exceed 1 microcurie
Americium-241**	Solid, Elemental	1 source not to exceed 0.1 microcurie

*Evaporated onto plastic film (Typical Bionuclear Inc., Houston, Texas.)

**Electrodeposited onto platinum foil (Typical Ortec Inc.)

These radioactive sources will be used for routine checks and calibrations of lithium-drifted silicon detectors, either in air or in a vacuum chamber. Because of their solid form and low activity, it is necessary to handle the sources with only a pair of small tongs.

3.4.1 Radiation Protection Program

The sources will be stored in locked, appropriately marked cabinets when not in use, with access to authorized users only. While the sources are not in use, they will be stored in a locked cabinet such that the dose level at the surface of the cabinet is ≤ 2 mr/hr. While in use, appropriate radiation signs will be placed at the 2 mr/hr locations.

In addition, personnel using the sources on a routine basis will wear film badges available from R. S. Laudauer, Jr. and Company.

3.4.2 Waste Disposal

At the end of the EPS program, the sources will be turned over to the NASA/MSU Health Physics Group for either storage or disposal. No wastes or disposal are expected to be necessary for these sources during the duration of the EPS program.

3.5 VAN DE GRAAFF FACILITY

An adequate safety program is already in existence at the Van de Graaff facility, and consists of the following:

- (1) The first time the accelerator is operated in each of the three modes, (low energy proton, high energy proton, and electron mode) Health Physics will be notified to perform a radiation survey for that mode.
- (2) Prior to each accelerator startup, the operating supervisor or his alternate shall be responsible to see that the following control procedure is accomplished:
 - a. Physically check each entrance into the target area to insure that the interlock system is functioning correctly.
 - b. Inspect the target room before each accelerator startup to verify that no one is present.
 - c. Check the visual warning system to insure that all units are operating correctly.
 - d. Check the area monitoring system panel to insure that all monitors are operating.

- e. Announce over the building intercom system, two (2) minutes prior to each startup, that accelerator operations will commence immediately.
 - f. Check the roof area for occupancy restrictions when required for a particular mode of operation.
 - g. Insure that an approved operator is at the console panel during accelerator operation.
3. It shall be the responsibility of the facility supervisor to maintain an OPERATION LOG. This record will indicate modes of operation and duration of each operation, e.g., target used, current, voltage and time spent on each mode of operation.
4. Approval must be received from the Radiological Control Officer (RCO) before anyone is allowed in the target room during radiation producing operations.
5. During the period covered by Machine Use Request 000225 (April 15, 1971 to February 1, 1972), no modifications will be performed on the accelerator facilities without authorization from the RCO.
6. In the event of a RADIOLOGICAL EMERGENCY, operations will be suspended and Health Physics notified immediately.
7. The roof area will be roped off and posted "Caution Radiation Area" during electron, proton and neutron production.
8. The doors to the accelerator target room will be posted as restricted areas at all times and will be posted "Caution High Radiation Area."

3.6 ENVIRONMENTAL CHAMBERS FACILITIES

NASA/MSC Environmental Facilities will be used for Qualification Testing and other environmental testing. These facilities have their own safety program approved by NASA/MSC.

3.7 CONTROL SYSTEM TEST FACILITIES

All environmental chambers located in the Lockheed Facility test area have been checked for safety features, and personnel using these facilities are aware of the procedures and cautions.

3.8 END ITEM ASSEMBLY

Maximum efforts have been made during design to ensure that the optimum degree of inherent safety has been included in all equipment designed, procured, or leased for the EPS Program through the selection of appropriate equipment components and design features, and through the use of materials which are known to be hazard free.

Appropriate action has been taken to assure that necessary functions of the system will occur as required, and that no primary failures will cause a chain of dependent failures which would degrade system safety and create hazardous conditions.

The environmental and acceptance test procedures will be designed to reflect safety considerations in their testing operations. The safety of the operations as well as the ability of the procedures to enhance the inherent safety achieved in the subsystems and equipment is a prime consideration.

3.9 RADIO FREQUENCY (RF) RADIATION HAZARDS

The limit for equipment exposure to RF radiation has been established at 0.01 watt/square centimeter (CM^2) at any frequency. It is possible to encounter even higher power densities than this established safe maximum limit during the tests required by the Radio Frequency interference (RFI) tests; however, these high densities are localized. Susceptibility to fields and voltages from other circuits and equipment in the spacecraft was reduced to a practical minimum in the basic design of each assembly and sub-assembly. Primary consideration was given to components and circuits that are inherently free of susceptibility to magnetic fields at dc and audio frequencies. Preference was also given to circuits and components which are optimally free of susceptibility to transient voltage fluctuations and response to signals outside the intended operating frequency bands. The EPS is designed to withstand the transient supply voltage changes caused by the operation of other equipment in the spacecraft without degradation of operation. All digital logic has been designed to operate at as high a triggering voltage as feasible, definitely above the millivolt level. This design objective will provide optimum freedom from inadvertent operation due to stray pulses.

3.2.1.1.1 Location, Envelope Weight and Center-of-Gravity

The EPS was initially designated to be located on the Skylab Multiple Docking Adapter at which time a 15-pound maximum weight limitation was imposed on the design. Within approximately two months after the award of the EPS contract, however, notification was received that the EPS was to be relocated to the Command Service Module in the sector No. 3 fairing area by radial beam No. 2. At that time, a maximum weight limitation of 20 pounds was imposed. The relocation also dictated two major changes in the structural design of the envelope:

1) The mounting flange was to be about the mid-section of the EPS instead of at the base of the EPS, and 2) A structurally stronger envelope was required to withstand the exceptionally higher shock and acceleration g-forces associated with the new location. The resulting envelope weight for the Structural Test Unit was 21 pounds, the Engineering Test Unit, 22.5 pounds, and the Qualification Test Unit, 22.53 pounds.

The center-of-gravity, which remained at essentially the same point throughout the several packaging designs, is essentially the same as that for the Qualification Test Unit (see figure 1).

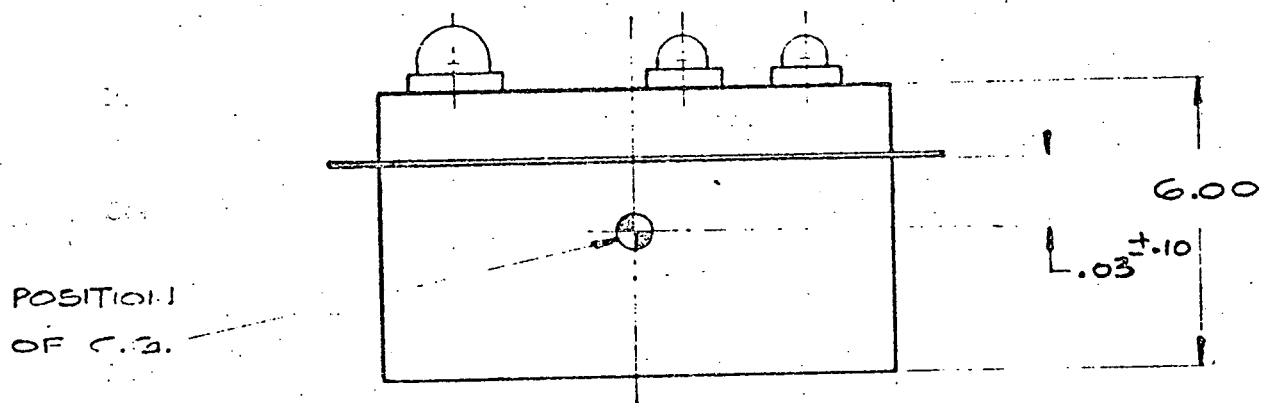
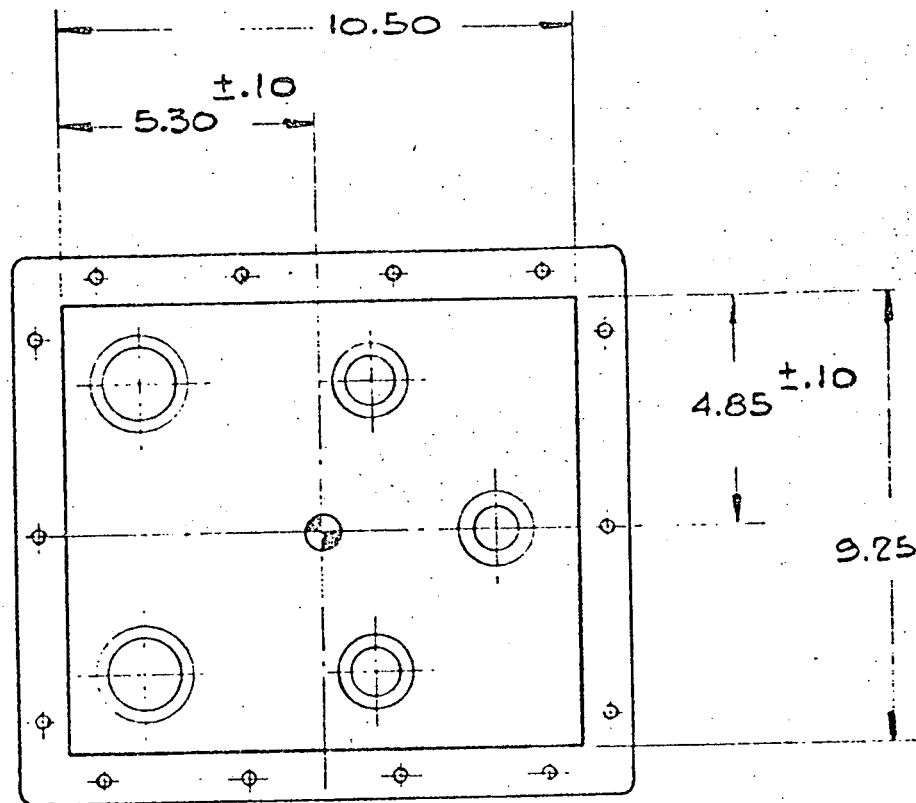


FIG. 1. MASS PROPERTIES STATUS
— POSITION OF C.G.

3.2.1.1.2 Structural

The following are documents applicable to the assessment of the structural requirements of the EPS.

<u>Subject Title</u>	<u>Page</u>
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Hermetic Sealing of EPS (EPS-5)	27
EPS Thermal Packaging Design (EPS-11)	29
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Vibration Test Report (Interim) on Solid State Radiation, Inc's. Lithium Ion Drift Detectors	98

ELECTRON-PROTON SPECTROMETER
PACKAGING DESIGN SPECIFICATION (GOALS)

1. Location - Mounted on multiple docking adaptor.
2. Instrument will be thermally isolated from vehicle skin.
3. Temperature Range, External - -180°F to $+277^{\circ}\text{F}$.
4. Temperature Range, Internal -

	Operating Mode	Standby Mode
Detectors	-58°F to $+32^{\circ}\text{F}$	-58°F to $+95^{\circ}\text{F}$
Electronics	-13°F to $+77^{\circ}\text{F}$	-13°F to $+158^{\circ}\text{F}$
5. Power
 - Electronics - 12 watts
 - Heaters - 3 watts available.
6. Package Size - $10'' \times 8'' \times 5''$ (400 cubic inches). (Detectors will protrude beyond 5" package height).
7. Weight - 15 lbs.
8. Operating Pressure - 10^{-8} torr.
9. General
 - a. Information on other environmental requirements is contained in MSC-01159, Rev. C "Flight Hardware Environmental Design Requirements", September 1, 1970.
 - b. It is presently planned that the detectors will be sealed units.
 - c. It is presently planned that the packaging design will provide conductive paths to the external walls of the package, to transmit heat from the electronics.
 - d. Electronics - Analog electronics will use P/C board techniques; digital and power supplies will most probably utilize welded cordwood modular techniques.

Ref. B - Temp. Range, Internal Mode: -58°F to $+32^{\circ}\text{F}$ was -13°F to $+77^{\circ}\text{F}$ and -13°F to $+77^{\circ}\text{F}$ was $+32^{\circ}\text{F}$ to $+122^{\circ}\text{F}$.

- I. Perform evaluation and initial analysis of existing design concept.
- II. Select suitable thermal coatings, investigate applicable thermal insulations.
- III. Based on specs and initial analysis of existing design, make recommendations to finalize design concept.
- IV. Provide liaison to LEC/HASD design engineering throughout the entire design phase.
- V. Perform thermal analysis of final thermal design and write report on results.

INTERDEPARTMENTAL COMMUNICATION

B. C. Hall

DEPT./ BLDG./ PLANT/ DATE
ORGN. 673-10 ZONE Beta FAC. HASD 11-12-70
EPS-5

FROM

D. L. Vincent

DEPT./ BLDG./ PLANT/ EXT.
ORGN. 673-10 ZONE Beta FAC. HASD 481

SUBJECT: Hermetic Sealing of EPS

It has been suggested that the EPS experiment be a completely hermetically sealed unit, so that it will not require documentation covering non-metallic materials, flammability, outgassing constituents, etc.

It is felt that this is a rather expensive way to avoid some documentation requirements. To design on the basis of a completely hermetically sealed unit will involve impact to the EPS program in several areas, such as:

- a. Invalidation of all previous design concepts studied.
- b. Need for investigation into suitable sealing techniques and seal testing that was not included in the original proposal. The difficulty of sealing for a five year period (one year operational) has not yet been established, but true hermetic sealing is both costly and time consuming to design and produce.
- c. Invalidation of all preliminary thermal analysis undertaken by LMSC.
- d. Elimination of multilayer insulation as a possible insulation technique. This material is only satisfactory under vacuum conditions.
- e. Weight - the casing would now have to withstand a differential pressure of 15 psi. This would possibly lead to an increase in weight.
- f. Additional machining for seal(s) and sealing bolts would involve additional costs, as would the seal itself.

- g. If permanent (solder, welding) sealing techniques are used, then increased difficulty of access to internal structure and circuitry would seriously hamper rework if and when required.

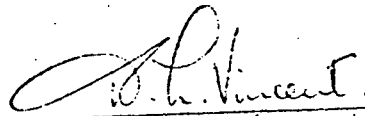
While the above may not be exhaustive, it gives a measure of the impact associated with this decision. In contrast to this, it is felt that if the materials used in the construction of the EPS are selected from materials already approved for use in the Apollo program (ref. 1, 2 and 3), much of the documentation and testing is already covered.

Experience has shown that the outgassing from the average experiment electronics is not excessive, where care has been exercised in the selection of materials used. Also, even when no attempt has been made to stabilize materials such as potting compounds, encapsulations and conformal coatings - sources of the major portion of the outgassing - the outgassing tends to stabilize itself in a short period of time. Should certain materials required to be used be a cause of excessive outgassing, it would probably be more economic to provide individual sealed containers at a component or subassembly level rather than at the general assembly level.

Finally, the EPS experiment will probably be a very small source of outgassing compared to that from the spacecraft itself.

Determination of whether the design should provide total hermetic sealing unit must be made very soon to avoid major schedule impact to the EPS project.

- Reference: 1. Grumman document LIS-360-22101
2. North American document MC 999-0058
3. Bendix document ATM 242.



D. L. Vincent

cc: B. E. Curtsinger
R. S. Lindsey
R. P. Dunn
P. Gleeson

INTERDEPARTMENTAL COMMUNICATION

TO D. L. Vincent DEPT./ 673-10 BLDG./ Beta PLANT/ HASD DATE 11-17-70
R. P. Dunn ORGN. ZONE FAC. EPS-11

FROM B. C. Hall DEPT./ 673-10 BLDG./ Beta PLANT/ HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT: Electron-Proton Spectrometer Thermal/Packaging Design

In order to achieve maximum progress in the thermal/packaging design of the EPS instrument, the following requirements will be considered firm and will be utilized until further notice.

1. Temperature Range, External: -180°F to +277°F
2. Temperature Range, Internal: Design goals

Instrument Subassembly	Operate Mode	Standby Mode
Detectors	0 + 25°C	-50°C to +35°C
Electronics	25°C ± 25°C	-25°C to +70°C
3. Mounting Location - MDA
4. Instrument will be thermally isolated from vehicle skin.
5. Weight: 15 lbs.
6. Vacuum seal - Not mandatory, design for thermally conductive paths from electronic components to a common heat sink using suitable encapsulating techniques.
7. Power: Electronics - 12 watts
Heater - 3 watts
8. Detectors: Will be hermetically sealed in TO-5 transistor package.
9. Packaging:
 - a. Analog electronics - use PC boards.
 - b. Digital and power electronics - use welded cordwood modular techniques.
10. Information on other environmental requirements can be found in MSC-01159 Rev. C "Flight Hardware Environmental Design Requirements", dated September 1, 1970.

cc: B. E. Curtsinger
R. S. Lindsey

B C Hall
B. C. Hall

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./673-10 BLDG./Beta PLANT/HASD DATE 12-16-70
ORGN. ZONE FAC. Ref: EPS-71

FROM D. L. Vincent

DEPT./673-10 BLDG./Beta PLANT/HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT: Thermally Conductive Substrates for Printed Circuit Boards
(Action Item 1, 12-14-70)

Investigation of thermally conductive substrates for printed circuit boards indicates that apart from the conventional glass-epoxy (a very poor thermal conductor) the choice resolves itself into one between the pure oxide ceramics and aluminum alloy.

The International Electronic Research Corp. markets a "metal core circuit board" consisting of an aluminum alloy (6061-T6) core, an "Insulube 448" insulation and copper conductor. This type of board is being used in many avionics applications (e.g. by Lockheed in the S3A). Generally, such a board is capable of providing five times the power dissipation of the glass-epoxy equivalent board. When a board is attached to a good "thermal ground", this power dissipation could rise to 12-15 times that of a glass-epoxy board.

National Beryllia Corp. are manufacturers of pure oxide ceramics, including alumina and beryllia substrates. Their Cermetrol Division has the capacity to manufacture a complete "printed circuit board".

The thermal conductivities of the substrates are:

Glass-Epoxy (G-10 Typical)	.0026	watts/cm-°C
Aluminum Alloy (6061-T6)	1.55	watts/cm-°C
Alumina (99.7% Al ₂ O ₃)	.35	watts/cm-°C
Beryllia (Berlox K120)	2.08	watts/cm-°C

However, the thermal conductivity is not a very good comparison of the relative efficiencies of the above materials as a thermally conductive substrate. Aluminum alloy, being an electrical conductor, needs a 4-5 mil insulating layer between it and the conductor.

A common concept for plates or sheets of material such as PC boards is resistance per square, and comparing these materials on this basis is a factual measure of their capabilities. Assuming, for comparison, a 1/16 inch thick board

Glass-Epoxy	2860 °C/watt
Aluminum (6061-T6)	4.06 °C/watt
Alumina	17.98°C/watt
Berlox K.120	3.309°C/watt

It can be seen that either the metal core circuit board or beryllia give the greatest improvement in heat dissipation over glass-epoxy. However, the aluminum board may have undesirable characteristics for use in some circuitry (such as capacitance in the op. amp. for EPS).

Ball park figures for cost are:

Aluminum Alloy Board (MCCB)

\$200 - \$300 for prototype board (about 3-1/2"x 2-1/4"-75 holes)

\$ 50 - \$100 for quantities ~ 25 (delivery ~10-12 weeks)

Beryllia

No cost figures available. Anticipate costs similar to aluminum alloy board above. (delivery ~ 8-10 weeks)

There is obviously no problem mechanically in using MCCB's, and preliminary calculations show that beryllia would be satisfactory.



D. L. Vincent

cc: Curtsinger
Dunn
Lindsey

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./ 673-10 BUDG./ Beta PLANT/ HASD DATE 12-30-70
 6294. 20343 Ref: EPS-92

FROM D. L. Vincent

DEPT./ 673-10 BUDG./ Beta PLANT/ HASD EXT. 422
 6294. 20343

SUBJECT: Interface of EPS with CSM

The writer received a telephone call from North American Rockwell, regarding interface information on mounting the EPS into the CSM. Discussion took place on the thermal and structural conditions, and they will be contacting B. E. Curtsinger and/or R. S. Lindsey to come to an agreement regarding the electrical interface. This is important to them.

They provided some general information regarding the temperature of the spacecraft in the immediate area for mounting the EPS, and the proposed concept for attaching us to the spacecraft.

Mr. Ed Schlessinger gave the following details.

1. We will be mounted on the shadow side of the spacecraft, though there exists the possibility that we may see the sun for a short period of time in one particular attitude of the spacecraft.
2. Temperatures of the access panel that we would be mounted in place of are:
 for varying β angle (angle between sun line and orbit plane)

β angle	Panel Temperature
-73 1/2°	-65°F
+73 1/2°	-80°F
0°	Temperature will vary in a sinusoidal fashion between -70°F and +25°F.
3. Within the spacecraft structure cavity the cavity wall temperature will range from 0°F to +50°F.

Mr. Squigley gave the following structural information.

1. We would be mounted on a flange on the access panel.
2. The EPS top plate would be 1-1/2" - 2" above the panel.
3. The approximate dimensions of the cavity are 14-1/2" x 12-1/2" x 7-1/2" deep. A more up-to-date sketch of the proposed mounting and cavity will be transmitted to NAR's Houston representative to pass on to us (it appears that the cavity is not a full rectangular box).

The writer informed them that our envelope would be smaller than the 12" x 10" that they had allowed for, and gave a provisional size of 10"- 10-1/2" x 9" x 6" high (exclusive of the detectors).

It appears that there would be space to provide some thermal insulation within the cavity should we find that we require it to keep within our thermal parameters.

They had been given to understand that at least one of the detector shields was only about 2-3 mils thick, and were a little concerned about the possible susceptibility to damage this would mean. The writer advised them that the thinnest shields are 14 and 71 mils thick aluminum.

The writer also inquired about the type of mating connector they might wish us to use, mentioning that we had planned to use a connector of the type covered by a MSFC specification. It would appear that they have some requirements regarding the connector, and its location, but preferred to leave this until they had spoken about the electrical interface.

Finally, it does not appear that they have been officially "turned on" by NASA to mount us on the CSM as yet, but understand that the official "turn-on" is "in the mill".

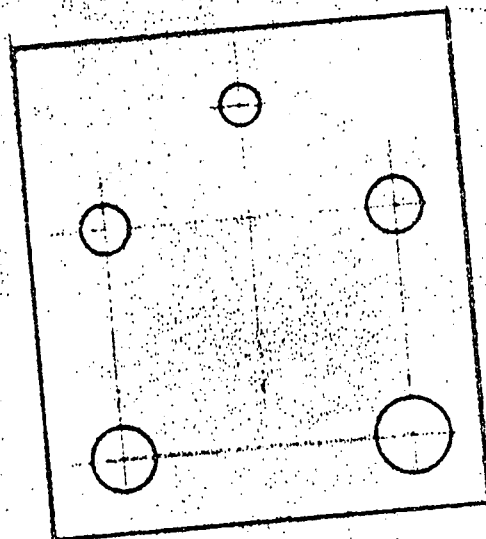

D. L. Vincent

cc: B. E. Curtsinger
R. P. Dunn
R. S. Lindsey

CHANNEL # 4

3.0" APPROX.

X₃₀₇₂



SPACECRAFT
STRUCTURE
CAVITY.

PANEL FACE

FAIRING
PANEL

X₆₂₂₅

BEAM Z

DIAGRAM OF FLUSH MOUNTING
OF E-PS. ON CSM.

BY R-30-70

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./ 673-10 BLDG./Beta PLANT/HASD DATE 1-13-71
CZONL ZONE FAC. Ref: EPS-104

FROM B. E. Curtsinger
D. L. Vincent

DEPT./ 673-10 BLDG./Beta PLANT/HASD EXT. 422
CZONL ZONE FAC.

SUBJECT: Results of the EPS/CSM Interface Meeting Held at North American Rockwell (NR) on 1-12-71

List of Attendees:

A. Farkas	NASA/MSC
P. Liles	NR/Downey
B. Curtsinger	LEC
D. Vincent	LEC
Various other NR personnel.	

Results:

After the North American Rockwell and Lockheed organizations and the basic operation of the EPS had been discussed, the four instrument to spacecraft interfaces were discussed in detail. These four interfaces are:

- A. Installation and Envelope
- B. Electrical and Functional
- C. Environmental
- D. Ground/Bench Test Equipment

Each of these interfaces will require an Interface Control Document which will be, in effect, a contractual agreement between NR and NASA/LEC.

Installation and Envelope:

LEC presented the drawing no. SMC39106411, "Outline Drawing - Electron Proton Spectrometer" for discussion and review. This drawing defines the overall size of the package and position and maximum projection of the detector housings. Despite the increase in size from the provisional size of 10" x 9" x 6" given approximately two weeks ago to the present size of 10-1/2" x 9-1/4" x 6", North American personnel were able to confirm that they can mount and install this size package, and provided a sketch of the required hole pattern in the mounting flange around the instrument.

The present maximum allowable weight of the instrument was given (20 lbs), and it was indicated that while we anticipated that we would be a little below this, no firm estimate was available at this date.

The type of connector mating with the spacecraft, and its position, was discussed. Agreement was reached on a ME 414-0096-0053 connector for the instrument with the mating connector being ME 414-0095-0061. North American said that these were available from Kierulf Electronics in Los Angeles (telephone no. 213-685-5511). They suggested contacting Miss Mildred Haller of that company. It may be that Kierulf has some of these connectors in stock, though normal delivery is 4-5 weeks. Regarding the connector position, LEC stated its preference for it to be at the bottom of the instrument, close to one of the 9-1/4" sides and to one side of the centerline of the instrument. North American needed to look into their wiring and connector layouts more closely before they could give a definite answer, but generally thought that this position would be acceptable to them. Some questions were raised regarding the projection of the connector below the base of the instrument. LEC indicated that we had some leeway in this area and would attempt to accommodate their needs as far as we could. NR will send their suggested position for the connector and its projection to A. Farkas (NASA/MSC) by the end of the week.

Installation into the spacecraft was discussed generally, and apart from some question of access to some components in the region of the instrument, did not appear to present any problems. The need for a handling container for the instrument and a protective shield for the detector if installation takes place at KSC was discussed, but no resolution was made.

All in all, the installation and envelope discussion was remarkably free of any problem areas.

Electrical and Functional:

A proposal was made by LEC to include an Analog to Digital converter in the EPS, thereby deleting the requirements for the two analog channels and the 1 pps sync signal. NR was very agreeable to this due to schedule and telemetry channel availability restrictions. Therefore, for the remainder of the discussion, it was assumed that an A/D converter would be included in the EPS.

NR had performed tests to determine if the tape recorder/VCO telemetry channel had sufficient bandwidth to accept a serial 220 bit per second, bi-phase-level PCM signal. The results of these tests indicated that this was acceptable. It is not known, at this time, whether the existing Skylab ground telemetry stations will accept this signal.

The power interface (including the uplink command control requirement) was discussed and is agreeable to both groups.

North American Rockwell has a specification for RFI/EMI and will include this document in the ICD. This specification has not been reviewed for compatibility with existing requirements.

The availability of an EPS for spacecraft functional tests (on 6-21-71) was discussed. Mr. Farkas suggested that the Engineering Test Unit be used for these tests. It was pointed out by LEC that the Engineering Test Unit will not have QA coverage during fabrication, and this would probably prevent the unit from being connected to the spacecraft. NR agreed. It was decided that NASA and NR would resolve this problem.

Environmental:

This discussion centered around the Environmental ICD and its format. The environmental requirements covered were:

1. Thermal
2. Shock and Vibration
3. Nuclear Radiation
4. Pressure
5. Magnetic Field
6. Other environmental factors.

These areas were discussed, primarily from the point of view of NR's need-to-know in terms of integration into the spacecraft as a system, and the EPS possible interaction with other instrumentation.

Thermal:

This covers surface materials and properties, thermal coating characteristics, temperature control means, range and set points, thermal analytical model, heat sources and/or sinks and conductance values.

The primary need for control of this information is integration into the thermal engineering of the spacecraft plus the need for knowledge of the type of materials and surface coatings that would be handled on installation in the spacecraft. Most of the information required could well be supplied by direct liaison between E. Schlessinger (NR's Thermal Engineer) and Don Smith (LMSC), particularly in the area of the analytical model (a very simple model).

LEC raised the possible need to heat sink the experiment to the spacecraft and possibly insulate the instrument from the cavity within the spacecraft skin. There appears to be no problem in this approach if needed.

From discussion of the Functional ICD, there is a need to define any temperature requirements in terms of time also, as in two modes of spacecraft operations, we could be on the sunward side of the spacecraft. One of these is during the docking maneuver, the other is during an "earth resources" mode.

Shock and Vibration:

NA will supply the shock and vibration levels at the mounting surface of the instrument in the near future.

Nuclear Radiation:

It was accepted that we had no radiation source, and that we measured electron and proton radiation levels. A statement to this effect will be included.

Pressure:

This covers any limitations on the instrument operation due to gas release, RCS burns, etc. The primary effect would be slight degradation of the thermal coating surfaces. LEC confirmed that we would be looking at the instrument for the need to vent any internal atmospheric pressure during the launch and orbit insertion sequences.

Magnetic Fields:

This would cover transient magnetic fields, and LEC could give no definite figures at this time.

Other Environmental Factors:

This would cover any other needs of the instrument not covered elsewhere. At this time neither LEC nor NR had any items to include under this heading. The question of accoustics was raised by A. Farkas. NR replied that this was normally included in the vibration levels to the instrument.

Ground/Bench Test Equipment:

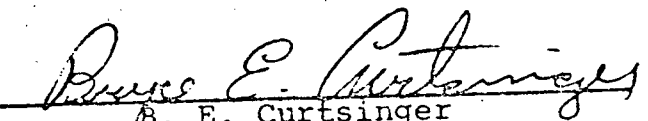
Since the EPS instruments are not to be installed on the Spacecraft at the North American plant at Downey, there is no requirement for tests or equipment at that location. However, NR strongly recommends that several tests be performed at Cape Kennedy.

Immediately after the EPS arrives at KSC, the unit should be subjected to a pre-installation test. This test would require bench test equipment and QA coverage.

Since the time between installation of the instrument on the spacecraft and launch could be as long as four months, NR recommends that equipment be provided to allow for functional tests of the EPS while installed on the CSM. This would require GSE and QA coverage.

Summary:

From the information obtained at this meeting, and from possible phone conversations in the future, North American Rockwell will prepare the ICD's for each interface. These will be sent to NASA and LEC for concurrence before the final drafts are prepared.


B. E. Curtsinger


D. L. Vincent

cc: B. E. Cash
R. P. Dunn
C. L. Fletcher
P. Gleeson
R. B. Hendrix
R. S. Lindsey
T. D. Lyons
W. A. Oliveira
R. W. O'Neill
C. J. Spahn

INTERDEPARTMENTAL COMMUNICATION

B. C. Hall

DEPT./ 673-10 BLDG./Beta PLANT/ HASD DATE 3-23-71
ORGN. ZONE FAC. Ref: EPS-174

FROM

D. L. Vincent

DEPT./ 673-10 BLDG./Beta PLANT/ HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT:

Preliminary Results of Thermal Analysis

The advance results from LMSC regarding the temperatures of the EPS show that these fall within the range of the packaging design specification (EPS-19, Rev. B) provided.

Cold orbit temperatures were predicated on 15.9W (12.9W electronics power + 3.0W heater power) while hot orbit temperatures are based on 12.9W electronics power only. The experiment is considered as mounted on the spacecraft structure via a glass-fiber mounting flange, or isolated in a manner to provide an equivalent thermal resistance at this point.

The specified temperature limits and the analysis results are tabulated below.

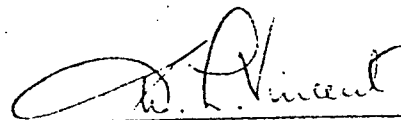
	Detectors	Electronics
Specified Limits	-58°F to +32°F (-50°C to +0°C)	-13°F to +77°F (-25°C to +25°C)
<u>Hot Orbit</u>		
Orbit Average	+12°F (-11.1°C)	+35°F (+1.7°C)
Temperature Range	+27°F to +1°F (-2.8°C to -17.2°C)	+37°F to +32°F (+2.8°C to +0°C)
<u>Cold Orbit</u>		
Orbit Average	-24°F (-31.1°C)	+2°F (-16.7°C)
Temperature Range	-22°F to -26°F (-30°C to -32.2°C)	+1°F (+1/2°C)

	Detectors	Electronics
*Cold Orbit (18.9W)		
Orbit Average	-12°F (-24.4°C)	+12°F (-11.1°C)
Temperature Range	-10°F to -14°F (-23.3°C to -25.6°C)	+1°F (+1/2°C)

*Estimated temperatures based on 6 watts of heater power in cold orbit.

An examination of these results shows that for the hot orbit, the detector and electronics temperatures fluctuate more widely than for the cold orbit. The detector temperature can rise to within 5°F of the maximum specified temperature, whereas the electronics are about 3°F above the mean (or nominal) specified temperature. In the cold orbit, the detectors are about 9°F below the mean specified temperature and the electronics are 13°F above the minimum specified temperature. The electronics temperature could be raised 10°F in the cold mode by the addition of an extra 3.0W of heater power, and this would raise the detector temperature by about the same amount. Figure 1 shows these results in a tabular form.

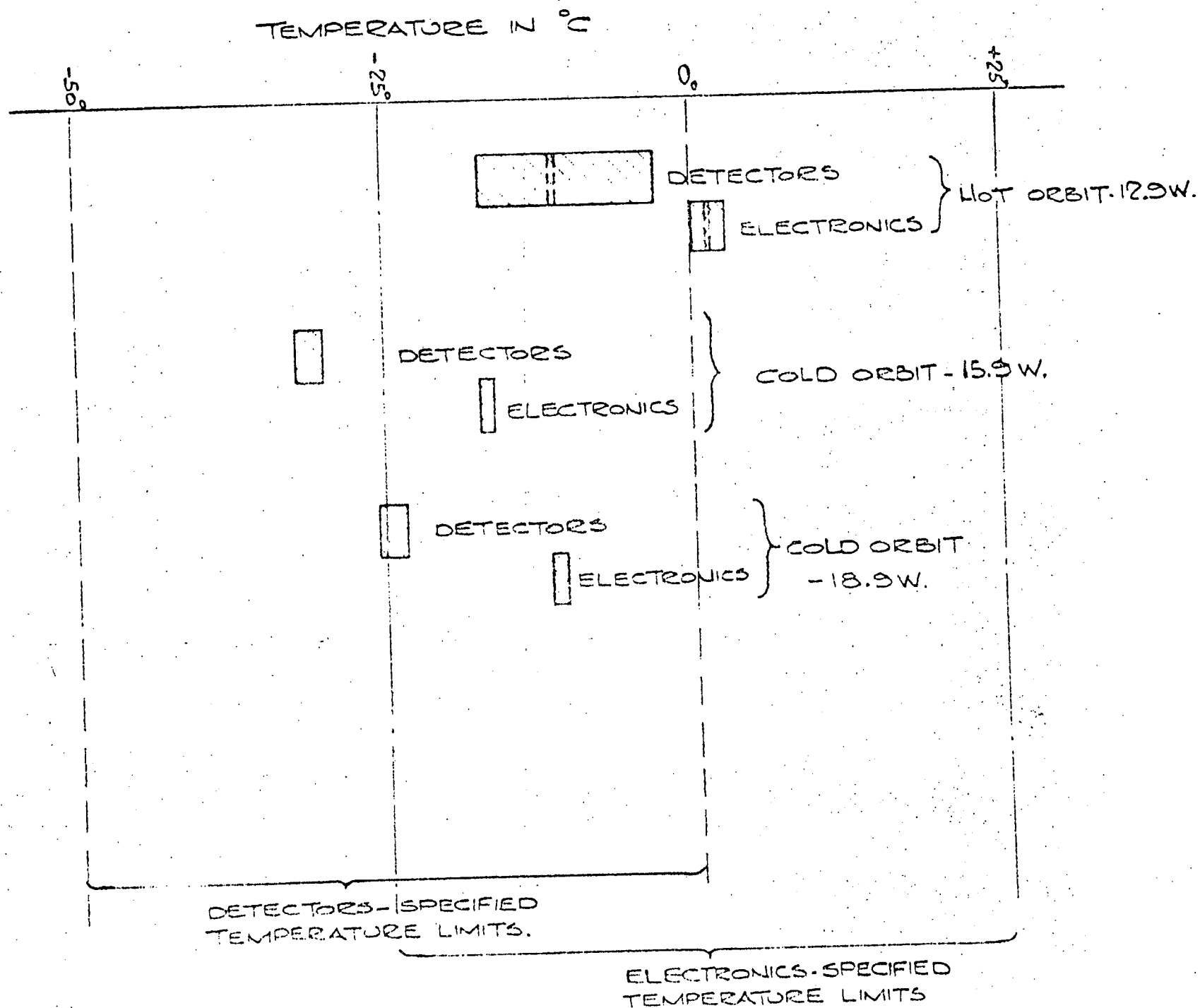
As a rough estimation of the thermal advantage of changing to a glass-fiber mounting flange, it would require a total power consumption 25.9W to maintain the cold mode temperatures at those for 15.9W.



D. L. Vincent

cc: B. L. Cash
B. E. Curtsinger
R. P. Dunn
P. Gleeson
R. B. Hendrix
R. S. Lindsey
C. J. Spahn

FIG. 1. - OPERATING TEMPERATURES, EPS.



INTERDEPARTMENTAL COMMUNICATION

VB. C. Hall

DEPT. /
ORIGIN 673-10

BLDG. /
ZONE Beta

PLANT /
FAC. HASD

DATE 4-9-71
Ref: EPS-194

FROM

D. L. Vincent

DEPT. /
ORIGIN 673-10

BLDG. /
ZONE Beta

PLANT /
FAC. HASD

EXT. 422

SUBJECT:

Comments on the Thermal Design Analysis (TXA 50-131) from LMSC
- April 1, 1971

An initial perusal of the above thermal design analysis report has presented no surprises or major deviation from information provided to the writer by D. H. Morton (LMSC) by phone.

Specific comments on the recommended thermal design provisions are as follows.

1. Thermal control surfaces

The proposed use of the White thermatrol paint and Mystic tape had been made known to us, and the design caters for this. D. Morton has provided the writer with LMSC's Material Specification, Process Bulletin and Process Specification (for protection of thermal control surfaces) for this material.

2. Electronics/Baseplate Interface

The change from 1/16" thick x 20.10 sq. ins. to 1/8" thick x 15.20 sq. ins. of fiberglass, providing approximately a 20°F increase in the electronics operating temperature, was provided by D. Morton and the necessary details are in the process of being modified. The proposal for the connecting screws is already incorporated in the design.

3. EPS/Spacecraft Interface

The proposal of a fiberglass flange came from LEC (as an alternative to a multitude of spacers and a possible requirement for NAR to isolate the hold-down bolts from the spacecraft structure). The present design incorporates this flange and the conduction path length is as recommended.

4. Heater Power Requirements

This paragraph did contain information not previously transmitted. The writer had advised LMSC that we monitored the temperatures, but that there was no provision to turn the instrument off, except through ground command. Possibly, this can be loosely interpreted as thermostatic control. The recommended "turn-on" temperatures for the heaters had not been transmitted, and the writer understands from B. Curt-singer that the heater control circuit is designed for "turn-on" at 0°C (32°F) and "turn-off" at +10°C (+50°F).

The request to examine the possibility of leaving the smallest detector dome unpainted was made due to the required thickness of the paint coating (4-6 mils). Discussion with B. Cash indicated that this thickness of paint on a dome of only 14 mils thickness would lead to either alteration of the energy levels measured by that detector or reduction of the required thickness of the dome by some amount that would, of necessity, have to await the results of test investigation of the effect of the paint coating. LMSC evaluated the thermal effect of leaving this dome unpainted, with the result that the change in temperature was insignificant. Therefore, the design does not require this dome to be painted.

Regarding the "stand-by" case (presumed to reflect possible rendezvous and docking situation) the report clearly indicates that these are worst-case situations. And the final sentence indicates that once again NAR has "backed off" from their initial input on the worst case parameters for the rendezvous and docking mode, which was in the order of potentially 7-10 days - with the EPS facing the sun - as a design requirement!

4-9-71
EPS-194
Page 3

Comparing the temperature results with those given in "Preliminary Results of Thermal Analysis" EPS-174 (3-23-71) written prior to the change in the electronics/baseplate interface, we have:

Hot Orbit

Detectors: Orbit average and temperature range remain the same.

Electronics: Orbit average 62°F (16.7°C)
Temperature range $\pm 1^\circ\text{C}$

Cold Orbit (3W heater power)

Detectors: Orbit average and temperature range remain the same.

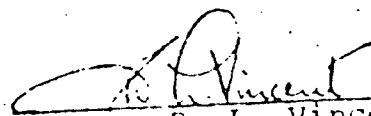
Electronics: Orbit average +17°F (-8.3°C)
Temperature range $\pm 1/2^\circ\text{C}$

Cold Orbit (6W heater power)

Detectors: Orbit average and temperature range remain the same.

Electronics: Orbit average +37°F (+2.8°C)
Temperature Range $\pm 1/2^\circ\text{C}$

These results show that the alteration in the electronics/baseplate interface has provided an increase in the electronics operating temperatures without any significant change in the equivalent detector operating temperatures. The only outstanding item in the design (from a thermal standpoint) is the determination of the desired heater power. There is no obstacle in the present design to prevent the use of 3W or 6W, and as it seems to be desirable that the electronics operate at as warm a temperature as possible in the cold mode then, power allotment permitting, the writer suggests that we use 6W heater power.


P. L. Vincent

cc: B. L. Cash
B. E. Curtsinger
R. P. Dunn
P. Gleeson
R. B. Hendrix
R. S. Lindsey
C. J. Spahn

INTERDEPARTMENTAL COMMUNICATION

B. E. Curtsinger

DEPT./ BLDG./ PLANT/ DATE
ORGN. 673-10 ZONE Beta FAC. HASD 4-15-71
Ref: EPS-200

FROM D. L. Vincent

DEPT./ BLDG./ PLANT/ EXT.
ORGN. 673-10 ZONE Beta FAC. HASD 422

SUBJECT: Additional Thermal Analysis Results

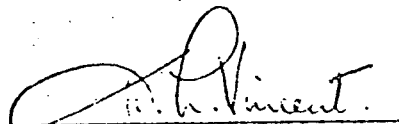
At the time the thermal report was discussed, it was noticed that two previous points raised had been omitted. These were:

- a. What is the minimum temperature of the electronics with all power off?
- b. What is the minimum temperature of the electronics with 6W of heater power only? If this is below -50°C , what is the minimum power requirement to maintain the electronics at or above -50°C ?

The answer to these questions was given by LMSC as:

- | | |
|--------------------------|---|
| a. All power off: | Electronics Temp -100°F (-73.3°C)
Detector Temp -103°F (-75°C) |
| b. 6W heater power only: | Electronics Temp -54°F (-47.8°C)
Detector Temp -71°F (-57.2°C) |

As the 6W of heater power maintains the electronics at or slightly above -50°C , no attempt was made to find the power required to maintain the electronics at -50°C . Additional information provided was the detector temperature in these particular modes.


D. L. Vincent

cc: B. C. Hall
B. L. Cash
R. P. Dunn
P. Gleeson
T. L. Knox
R. S. Lindsey
C. J. Spahn

Handwritten:
Jensen

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall DEPT./ 673-10 BLDG./Beta PLANT/HASD DATE 2-8-71
ORGN. ZONE FAC. Ref: EPS-123

FROM D. L. Vincent DEPT./ 673-10 BLDG./Beta PLANT/HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT: Random Vibration Criteria for EPS

The vibration criteria for the EPS when mounted into the CSM fairing was received from Mr. A. Farkas (NASA/MSC) on 2-4-71. This information had been provided by North American in a telefax.

Review of the information led to an immediate query of the very high power spectral density levels involved. Mr. Paul Liles (NAR) confirmed the $6.0 \text{ g}^2/\text{Hz}$ level to Mr. Farkas, and these levels were confirmed independently of NAR by Mr. Farkas. These levels are apparently factual levels based on the monitored results of two tests, and are applicable to the EPS for any mounting position in the CSM fairing. Mr. Farkas states that these levels would be the test levels for the EPS, though the writer can find no indication in the telefax that these are other than flight environment levels. If they are flight levels or acceptance test levels, then the qualification test levels would be significantly higher (e.g. $6 \text{ g}^2/\text{Hz} \times 1.3^2 = 10.14 \text{ g}^2/\text{Hz}$). The question of what levels we will be contractually obligated to test to needs some clarification.

It is obvious that these high levels will have an impact on the design of the EPS. Not only is it necessary to re-examine the structural design in the light of the new criteria, but it will also be necessary to investigate the internal packaging of all of the electronics in each slice. The vibration spectrum has its peak power levels between 100 - 1000 Hz; the natural frequency of the EPS will be somewhere between 100 - 350 Hz in all probability, as will that of the majority of components. The peak power input bandwidth is so wide that it is virtually impossible to design so that the instrument will not have a resonant frequency in this range. An investigation of the full impact of this to the packaging design must be made, but has not yet been started. If the writer had to hazard a guess, it would be that we will be extremely lucky if we avoid having to modify the design appreciably from its present size and weight.

At this point, a review of the history of the vibration criteria for the EPS is not amiss. Figure 1 shows the variety of random vibration criteria that we have received as design requirements.

The first was that contained in MSC-02814, Preliminary Requirements Review, Electron-Proton Spectrometer (11-6-70):

20 - 80 Hz @ 3 dB/Octave increase	} Curve "A" Acceptance Test levels. 5 mins/axis
80 - 350 Hz @ .067 g ² /Hz	
350 - 2000 Hz @ 3 dB/Octave Decrease	

≈ 8.1 g r.m.s.

At this point in time, there was some uncertainty as to the location of the experiment on the MDA, and it was felt that the above specification was a fairly low one to design to. Therefore, the general specification for the MDA skin was selected from MSC-01159, Rev. C, "Flight Hardware, Environmental Design Requirements:

MDA Skin, Subzone 11-2

20 - 130 Hz @ .30 g ² /Hz	} Curve "B" 1 min/axis
130 - 220 Hz @ -6 dB/Octave	
220 - 800 Hz @ .10 g ² /Hz	
800 - 1400 Hz @ -12 dB/Octave	
1400 - 2000 Hz @ .010 g ² /Hz	

11.6 g r.m.s.

Detectors were vibration tested to these levels, and also the levels for the OWS LH₂ cylinder tank general specifications, subzone 4-3 (between 12-2-70 and 12-7-70 - see EPS 33 and 67).

20 Hz @ .010 g ² /Hz	} Curve "C" 1 min/axis
20 - 90 Hz @ +12 dB/Octave	
90 - 200 Hz @ 3.7 g ² /Hz	
200 - 500 Hz @ -12 dB/Octave	
500 - 2000 Hz @ .095 g ² /Hz	

29.1 g r.m.s.

The detectors successfully completed testing to both these levels. The OWS spectrum was run, as the workshop was being considered as an alternative location for the EPS. However, design was based on the MDA skin criteria, though it was recognized that these levels might be increased a little, dependent on the location of the experiment, so somewhat larger factors of safety were used in the initial design than would normally be called for to achieve an economical, light-weight design.

On 12-16-70, an interface meeting was held between LEC, NASA and Martin-Denver. At this time we were given a location on the MDA - the L-Band Radiometer Truss - and its accompanying vibration requirements.

20 - 183 Hz @ 1.0 g^2 /Hz	}	Curve "D" 1 min/axis
183 - 554 Hz @ -12 dB/Octave		
554 - 750 Hz @ .012 g^2 /Hz		
750 - 1300 Hz @ -12 dB/Octave		
1300 - 2000 Hz @ .0013 g^2 /Hz		

15.1 g r.m.s.

Investigation indicated that our design could accomodate this new criteria without significant impact on the detail design (EPS)72), mainly due to the large factors of safety used - as mentioned previously.

Approximately one week later, we were advised that the EPS would not be mounted on the MDA! A possible alternative position on the CSM was mentioned, and this was welcomed as probably leading to a reduction in the vibration criteria. General opinion was that the CSM vibration levels would be significantly lower than for the MDA. Even at the interface meeting with NAR, no mention was made of high vibration levels (EPS-104, 1-13-71).

CSM

20 - 175 Hz @ +6 dB/Octave	}	Curve "E" .80 secs + 10 secs @ 4 dB above nominal
175 - 350 Hz @ 6.0 g^2 /Hz		
350 - 2000 Hz @ -3 dB/Octave		

≈ 85.99 g r.m.s.

2-8-71
EPS-123
Page 4

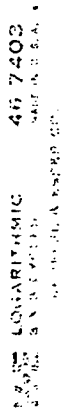
As can be seen from Curve "E", the power levels involved are considerably higher than any previous specification given, and certainly we have no large factors of safety now involved to offset the impact on the design.

The environment of this location on the CSM is not an ideal one for a sensitive instrument, and will almost certainly have an effect on our present design. Examination of the curves shows that the CSM criteria is significantly greater than the OWS spectrum to which we subjected the detectors (as a "worst case" test), and it is interesting to note how the vibration level requirements have increased steadily since the project was first started. From the information that was first provided for design, it would have been impossible to forecast the levels now imposed.



D. L. Vincent

cc: B. E. Curtsinger
R. P. Dunn
P. Gleeson
R. B. Hendrix
R. S. Lindsey
C. J. Spahn



CURVE 'A' - PRELIM. REQUIREMENTS REVIEW 11-6-70
CURVE 'B' - MDA CYLINDER DATA, GEN. SPEC.
CURVE 'C' - OWS LN₂ CYLINDER TANK SECTION

CURVE D' - MDA L-RAND RADIOMETER
TRUES - MARTIN, DENVER-12 -
CURVE E' - CSM FAIRING - MAR-2-4-7

BY DGP DATE 10/12/71 SUBJECT E/P SENSOR SHEET NO. 0 OF 13
CHKD. BY _____ DATE _____ QUAL MODEL JOB NO. _____

ELECTRON / PROTON SENSOR
COMBINED PRESSURE
AND RANDOM
VIBRATION

THE STRUCTURAL INTEGRITY OF THE E/P SENSOR HARDWARE HAS BEEN DEMONSTRATED BY A SERIES OF SINUSOIDAL, RANDOM, AND SHOCK TEST ENVIRONMENTS BEING APPLIED TO THE ENGINEERING TEST MODEL. THE ACTUAL FLIGHT ENVIRONMENT WILL SUBJECT THE INSTRUMENT TO A LOAD COMBINATION WHICH WOULD BE BOTH DIFFICULT AND EXPENSIVE TO DUPLICATE. THIS LOADING IS A SUPERPOSITION OF PRESSURE ON THE INSTRUMENT BASE PLATE AND A MAXIMUM RANDOM VIBRATION SPECTRUM APPLIED THROUGH THE EIGHT MOUNTING LOCATIONS.

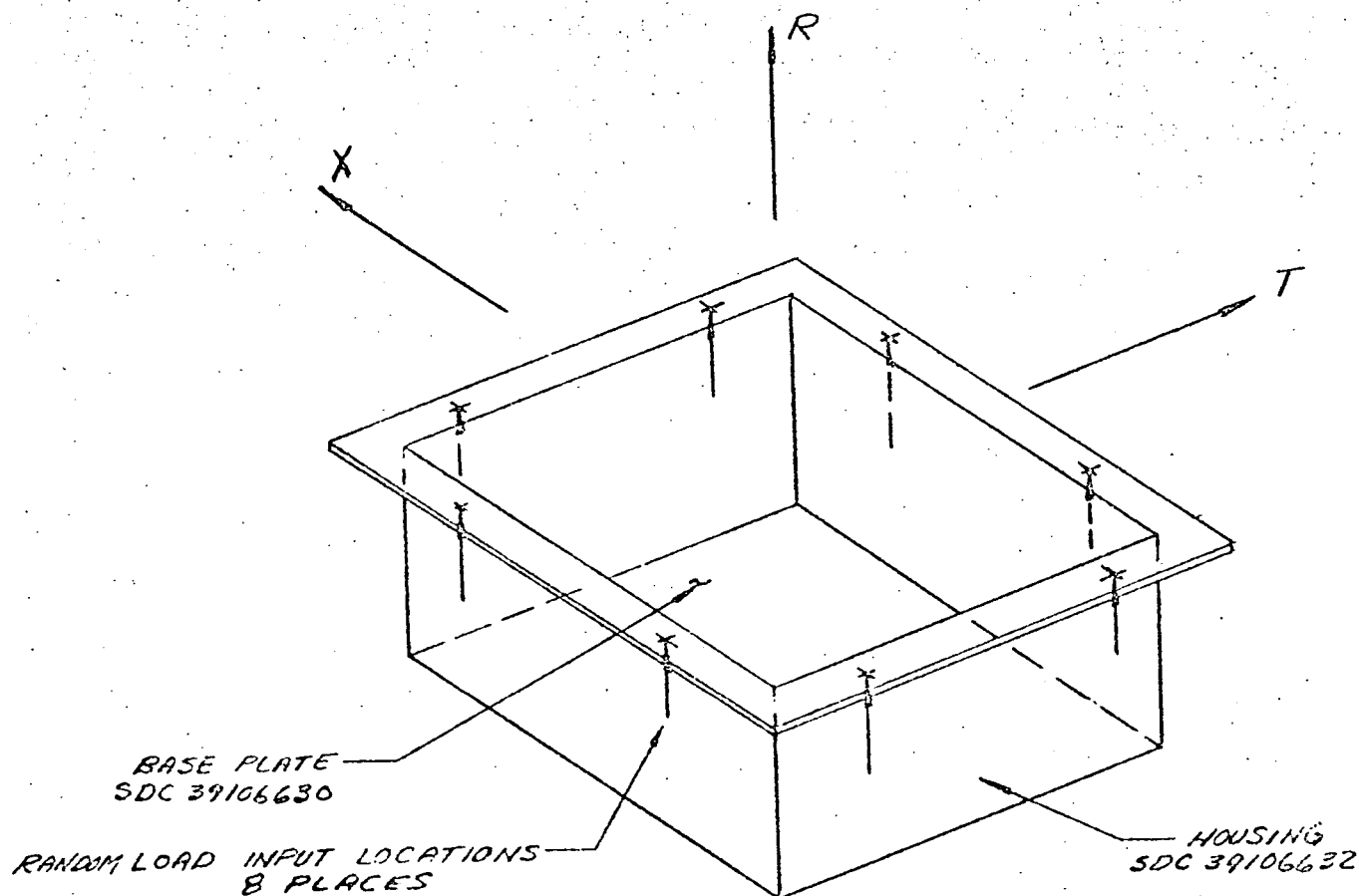
THE ENCLOSED STRESS ANALYSIS IS PRESENTED TO VERIFY THE ADEQUACY OF THE E/P SENSOR TO THE COMBINED PRESSURE AND VIBRATION LOADING.

MINIMUM MARGINS OF SAFETY WERE FOUND ON THE ENCLOSURE BASE PLATE (SDC 39106620). THE LOWEST MARGIN WAS +.08 ON ULTIMATE LOADING.

BY DGP DATE 10/6/71 SUBJECT E/P SENSOR
CHKD. BY _____ DATE _____ QUAL. MODEL

SHEET NO. 1 OF _____
JOB NO. _____

STRESS CALCULATIONS FOR HARD MOUNTED
BOTTOM PLATE

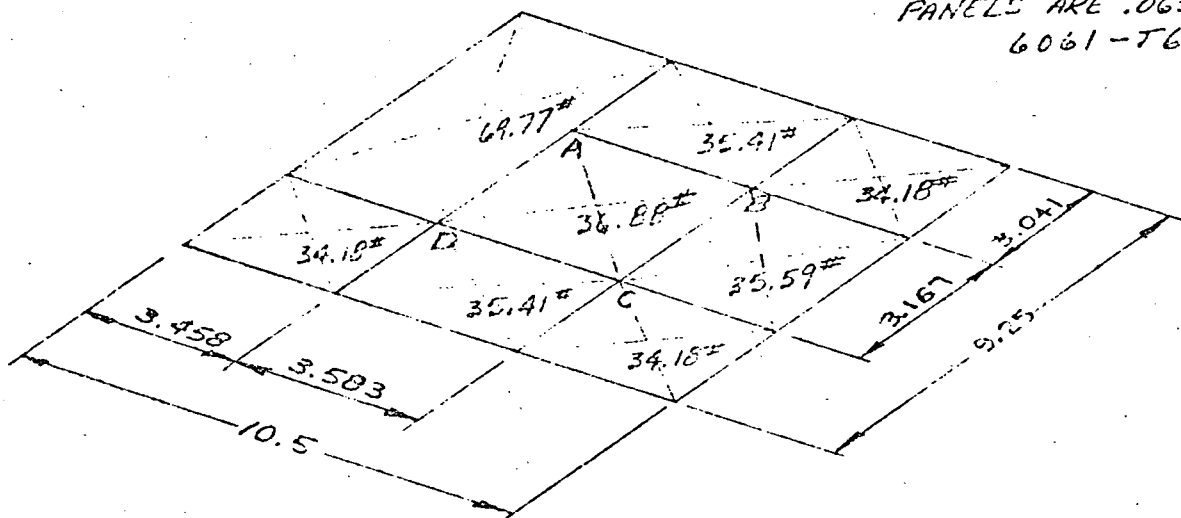


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CALCULATION OF PRESSURE LOADS ON PANELS & DISTRIBUTION TO BEAMS.

PANELS ARE .063 ALUM.
6061-T6



A MAXIMUM PRESSURE OF 3.25 PSI WAS READ FROM
NAR ENVIRONMENTAL SPEC MH04-02120-434

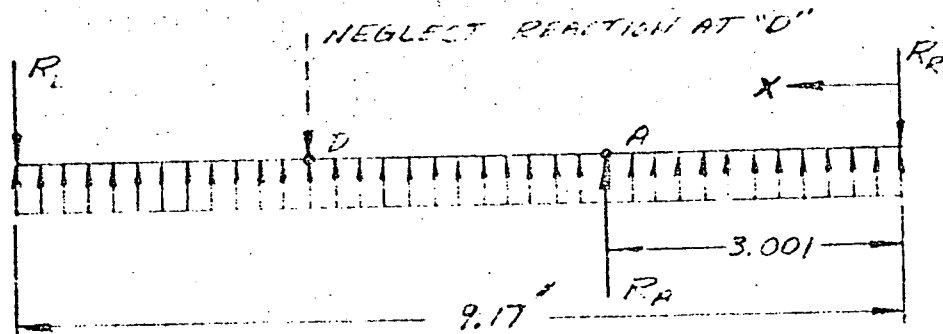
PANEL PRESSURE LOADS (LIMIT)

$3.25 \times 3.458 \times 3.041$	$= 34.18^{\#}$	(2)	102.54
$3.25 \times 3.458 \times 3.167$	$= 35.59$	(1)	35.59
$3.25 \times 3.458 \times 6.208$	$= 69.77$	(1)	69.77
$3.25 \times 3.583 \times 3.041$	$= 35.41$	(2)	70.82
$3.25 \times 3.583 \times 3.167$	$= 36.88$	(1)	36.88
TOTAL			315.60 [#]
$3.25 \times 10.5 \times 9.25$	$= 315.66^{\#}$	CHECK	

DISTRIBUTE $\frac{1}{4}$ OF TOTAL PANEL LOAD TO EACH
PANEL EDGE BEAM.

PRESSURE LOAD CALCULATION (CONT'D) ✓

THE CRITICAL BEAM WILL BE BEAM "AD" AS SHOWN BELOW.



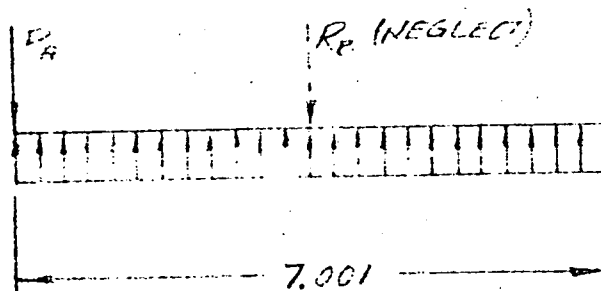
TOTAL DISTRIBUTED LOAD ON BEAM "AD"

$$W = (69.77 + 35.41 + 36.88 + 34.18 + 35.41) \times .25$$

$$= 52.91 \text{ #}$$

$$W = 52.91 / 9.17 = 5.77 \text{ #/IN.}$$

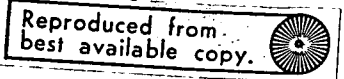
REACTION R_A



$$W = (35.41 + 34.18 + 36.88 + 35.41) \times .25$$

$$= 35.51 \text{ #}$$

$$R_A = W / 2 = 17.76 \text{ #}$$



PRESSURE LOAD CALCULATION (CONT'D)

DETERMINE MOMENT AT VARIOUS SECTIONS ALONG BEAM 'AD'

X BETWEEN R_R AND A

$$M = R_R X - \frac{1}{2} W X^2$$

$$R_R = \left[\left(-2.91 \times \frac{9.17}{2} \right) + \left(17.76 \times 6.129 \right) \right] / 9.17$$

$$= 38.32^{\#} \quad R_L = 38.35^{\#}$$

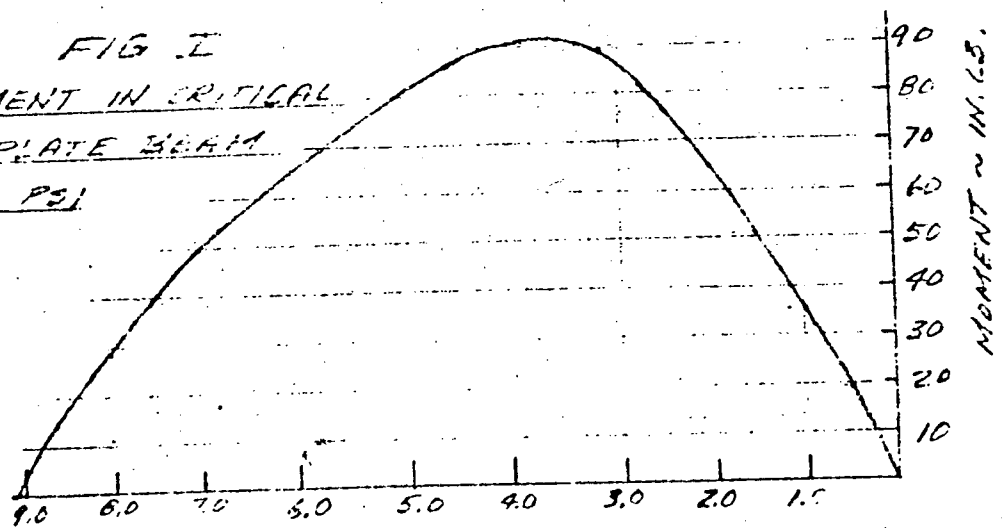
SECTION	X	R_R	X^2	$W X^2$	MOMENT
1	.5	19.16	.25	1.44	18.44
2	1.0	38.32	1.0	5.77	35.44
3	1.5	57.48	2.25	12.98	50.99
4	2.0	76.64	4.0	23.08	65.10
5	2.5	95.8	6.25	36.06	77.77
6	3.001	114.99	9.006	51.96	89.51

X BETWEEN A AND D

$$M = R_R X - \frac{1}{2} W X^2 - R_A (X - 3.001)$$

	X	R_R	X^2	$W X^2$	$X - 3.001$	$R_A (X - 3.001)$	MOMENT
7	4.585	175.76	21.02	121.30	1.584	28.13	86.92

FIG. I
 MOMENT IN CRITICAL
 BASE PLATE BEAM
 3.25 PSI



X DISTANCE FROM R_R ~ IN

64g RMS LOAD CALCULATION

CALCULATION OF THE VIBRATION TEST LOADING
R" AXIS VIBRATION

THE 'R' AXIS RANDOM VIBRATION TEST WAS RUN AT A 55g RMS LEVEL (TEST SPEC. CALLED FOR 64g RMS). THE BOTTOM PLATE INSTRUMENTATION CONSISTED OF ONLY ONE ACCELEROMETER WHICH WAS LOCATED APPROXIMATELY IN THE CENTER OF THE BOTTOM PLATE. THE ACCELEROMETER WAS POSITIONED TO MEASURE 'R' AXIS RESPONSE.

BECAUSE OF THE LIMITED INSTRUMENTATION THE ACCELERATION LEVELS OF SPECIFIC MODES CANNOT BE ISOLATED.

A CONSERVATIVE APPROACH IS TAKEN IN THE FOLLOWING CALCULATIONS TO ESTIMATE THE SHEARS AND MOMENTS OCCURRING IN THE BASE PLATE DURING 64g RMS 'R' AXIS EXCITATION.

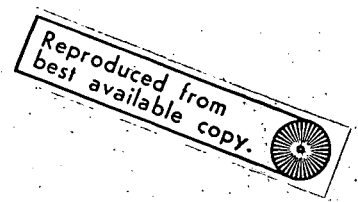
$$10 \text{ RMS } g's = 143 \times \frac{64}{55} = 166.2 \text{ g's RMS}$$

(143g WAS -10 RMS ACCELERATION FROM THE 55g RMS 'R' AXIS INPUT TEST)

30 ACCELERATION PEAKS WILL GO TO

$$3 \times 166.4 = 499.2 \text{ g's RMS}$$

THE METHOD TO BE USED TO CALCULATE BASE PLATE LOADS WILL BE TO ASSUME THAT THIS 499g RESPONSE IS THAT OF THE FIRST MODE AND ONLY THE FIRST MODE IS IMPORTANT. THE ACCELERATION WILL BE APPLIED UNIFORMLY TO THE OVERHUNG BASE PLATE TO SIMPLIFY THE CALCULATIONS.



64% VIBRATION TEST LOADING (CONT'D)

DETERMINE WEIGHT OF BOTTOM PLATE

	VOLUME
SKIN	6.022 IN ³
$9.25 \times 10.5 \times .062 =$	
CENTER RIBS	
$4 \times 3.583 \times .282 \times .08 =$	.323
$4 \times 3.167 \times .282 \times .08 =$	.286
TAPERED RIBS	
$8 \times 2.499 \times .125 \times .12 \times \frac{1}{2} =$	.150
$8 \times 2.773 \times .219 \times .08 \times \frac{1}{2} =$	.194
$5 \times 2.916 \times .125 \times .12 \times \frac{1}{2} =$	.109
$5 \times 2.539 \times .219 \times .08 \times \frac{1}{2} =$	.111
EDGE	
$39.5 \times [(.154 \times .234) - (.085 \times .094)] =$	1.126
INTERSECTION	
$2 \times .696 \times .696 \times .344 =$	.333
$+ .696 \times .616 \times .344 =$	.147
$+ .696 \times .457 \times .344 =$	.236
$- 4 \times 3.1416 \times .125^2 \times .344 =$	-.068
CONNECTOR BOSS & RIB	
$.75 \times 1.628 \times .16 \times \frac{1}{2} =$	.098
$1.562 \times .17 \times .08 \times \frac{1}{2} =$	.011
$2.956 \times .125 \times .431 \times \frac{1}{2} =$	.089
FILLETS	
$\frac{28}{16} \times .125 \times .375^2 \left(1 - \frac{\pi}{4}\right) =$	.026
$\frac{42}{16} \times .281 \times .315^2 \left(1 - \frac{\pi}{4}\right) =$	.317

TOTAL VOLUME 9.51 IN³

DENSITY OF 6061-T6 ALUMINUM = .098 #/IN³

TOTAL WEIGHT OF BASE PLATE

$$WT = 9.51 \times .098 = .93 \text{ #}$$

64g VIBRATION TEST LOADING (CONT'D.)

NOW THE EQUIVALENT TOTAL LOAD FROM VIBRATION BECOMES

$$499.2 \times .93 = 464 \text{#}$$

UNIT LOAD IS

$$464 / (10.5 \times 9.25) = 4.78 \text{#}/\text{IN}$$

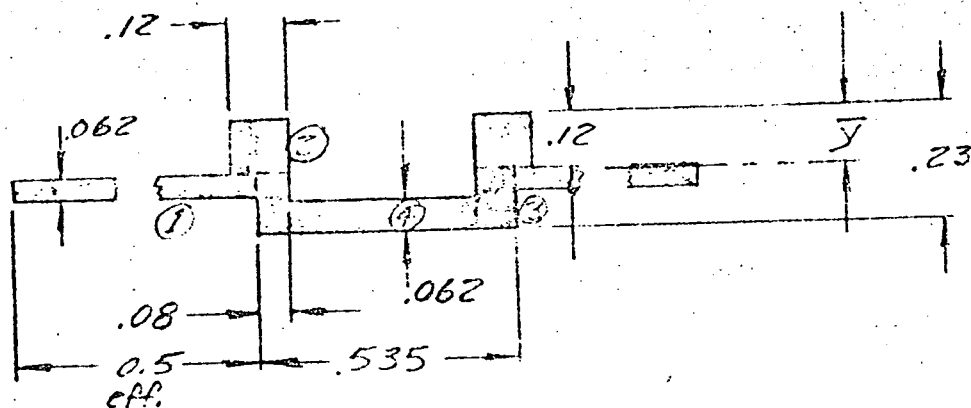
THE TOTAL LIMIT DESIGN LOAD AT ANY SECTION CAN NOW BE DETERMINED BY USING FIG I FOR OBTAINING THE PRESSURE MOMENT AT ANY DESIRED SECTION ON BEAM "AD", OUR ASSUMED CRITICAL BEAM, AND MULTIPLYING THE MOMENT FROM THE CURVE BY:

$$\text{FACTOR} = \frac{3.25}{3.25} + \frac{4.78}{3.25} = 1 + 1.47 = 2.47 \quad \left(\begin{array}{l} \text{IF PRESS. MOMENT} \\ \text{MOMENT IS } \times 2.47 \text{ IT} \\ \text{WILL GIVE TOTAL MOMENT} \end{array} \right)$$

SECTION	PRESS. MOM.	VIB. MOM.	TOTAL MOMENT (LIMIT)
1	18.44	27.11	45.55 IN LB.
2	35.44	52.10	87.54
3	50.99	74.96	125.95
4	65.10	95.7	160.80
5	77.77	114.32	192.09
6	89.01	130.84	219.85
7	96.92	127.77	214.69

BEAM 1.0" SECTION PROPERTIES

SECTION 1



ELEM	A	y	Ay	Ay ²	I _c	Tot
1	.062	.151	.00936	.00141	.00002	.00143
2	.0288	.06	.00173	.00010	.00003	.00013
3	.0176	.175	.00308	.00054	.00002	.00056
4	.0233	.199	.00464	.00092	.00001	.00093
Tot	.1317	—	.01881	.00297	.00008	.00305

$$\bar{y} = \frac{.01881}{.1317} = .1428 \text{ IN} \quad \bar{y}^2 = .0204 \text{ IN}^2$$

$$I_{yy} = .00305 - .1317(.0204) = .00036 \text{ IN}^4$$

$$Z_{yy} = .00254 \text{ IN}^3$$

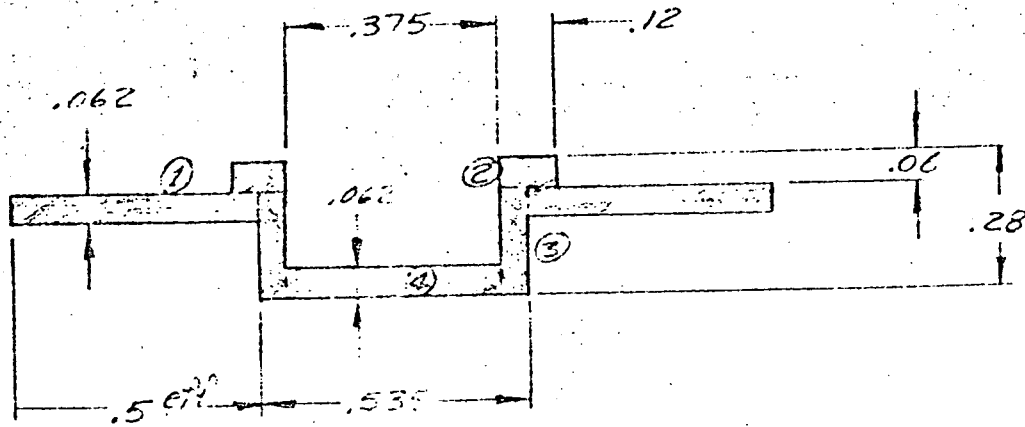
SECTION 2


$$\bar{y} = \frac{.01857}{.121} = .1535 \text{ IN} \quad \bar{y}^2 = .0192 \text{ IN}^2$$

$$Z_{\text{eff}} = \frac{.00054}{1.1288} = .00048 \text{ IN}^3$$

BEAM "AL" SECTION PROPERTIES (CONT'D)

SECTION 3



ELEM	A	y	Ay	Ay ²	I _o	TOT
1	.062	.091	.00564	.00051	.00002	.00053
2	.0144	.03	.00043	.00001	—	.00001
3	.0352	.17	.00598	.00102	.00020	.00122
4	.0233	.249	.00580	.00144	.00001	.00145
TOT	.1349	—	.01785	.00298	.00022	.00321

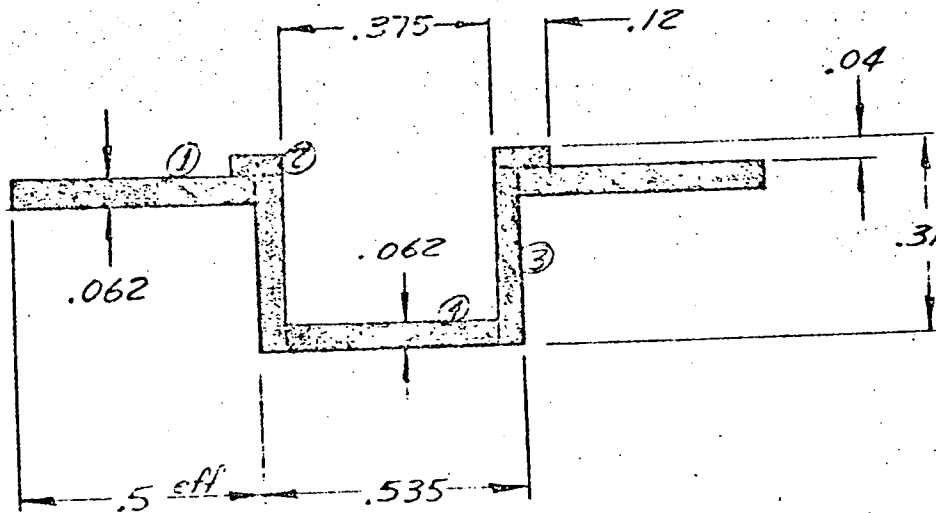
$$\bar{y} = \frac{.01785}{.1349} = .1323 \text{ IN.} \quad \bar{y}^2 = .0175 \text{ IN}^2$$

$$I_{yy} = .00321 - .1349(.0175) = .00085 \text{ IN}^4$$

$$Z_{yy} = \frac{.00085}{.1477} = .00575 \text{ IN}^3$$

BEAM "AC" SECTION PROPERTIES (CONT'D)

SECTION 4



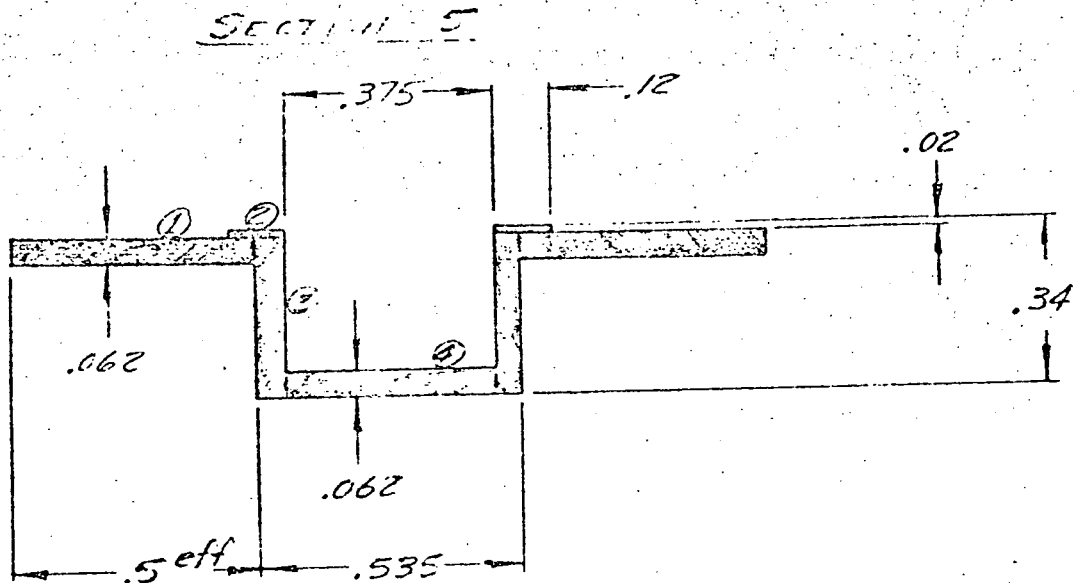
ELEM	A	y	Ay	Ay ²	I _o	TOT
1	.062	.071	.0044	.00031	.00002	.00033
2	.0096	.02	.00019	.00000	.00000	.00000
3	.0432	.175	.00756	.00132	.00026	.00158
4	.0233	.279	.00653	.00181	.00001	.00182
TOT	.1381	—	.01865	.00344	.00029	.00373

$$\bar{y} = \frac{.01865}{.1381} = .1353 \text{ IN.} \quad \bar{y}^2 = .0182 \text{ IN}^2$$

$$I_{yy} = .00373 - .1381(.0182) = .00121 \text{ IN}^4$$

$$Z_{yy} = \frac{.00121}{.175} = .00691 \text{ IN}^3$$

BEAM "AD" SECTION PROPERTIES (CONT'S)



ELEM	A	Y	A _y	A _y ²	I _o	TOT
1	.062	.051	.00316	.00016	.00002	.00018
2	.0048	.01	.00005	.00000	.00000	.00000
3	.0512	.18	.00922	.00166	.00040	.00206
4	.0233	.309	.00720	.00222	.00001	.00223
TOT	.1413	-	.01963	.00404	.00043	.00447

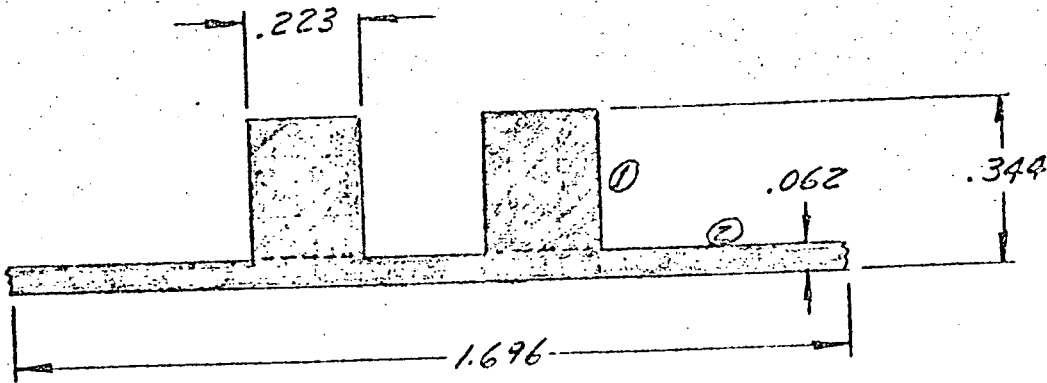
$$\bar{Y} = \frac{.01963}{.1413} = .1389 \text{ IN.} \quad \bar{Y}^2 = .01919 \text{ IN}^2$$

$$I_{yy} = .00447 - .1413(.01919) = .00176 \text{ IN}^4$$

$$Z_{yy} = \frac{.00176}{.2011} = .00875 \text{ IN}^3$$

BEAM "AD" SECTION PROPERTIES (CONT'D)

SECTION 6 (BEAM INTERSECTION)



ELEM	A	y	Ay	Ay ²	I ₀	TOT
1	.12577	.141	.01773	.00250	.00114	.00364
2	.10515	.313	.03291	.01030	.00003	.01033
TOT	.23092	—	.05064	.01280	.00117	.01397

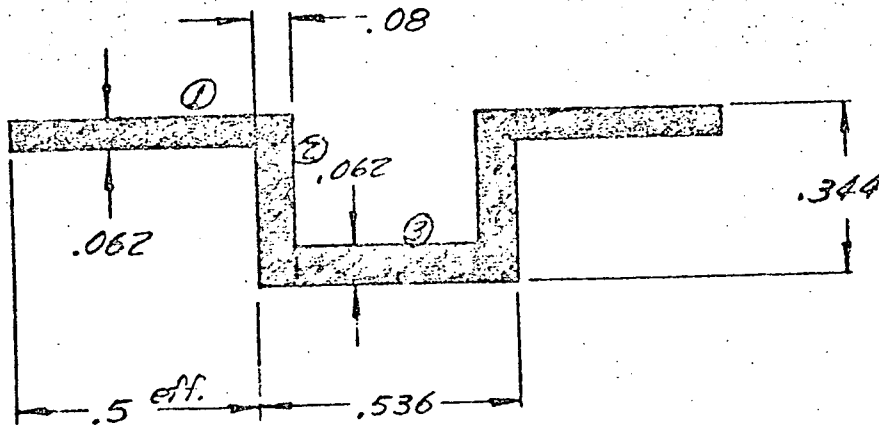
$$\bar{y} = \frac{.05064}{.23092} = .2193 \text{ IN.} \quad \bar{y}^2 = .04809 \text{ IN}^2$$

$$I_{yy} = .01397 - .23092(.04809) = .00287 \text{ IN}^4$$

$$Z_{yy} = \frac{.00287}{.2193} = .01309 \text{ IN}^3$$

BEAM "AD" SECTION PROPERTIES

SECTION 7



ELEM	A	Y	Ay	Ay ²	I _o	TOT
1	.062	.031	.00192	.00006	.00002	.00008
2	.05504	.172	.00947	.00163	.00054	.00217
3	.02325	.313	.00728	.00228	.00001	.00229
TOT.	.14029	-	.01867	.00397	.00057	.00454

$$\bar{y} = \frac{.01867}{.14029} = .13308 \quad \bar{y}^2 = .01771$$

$$I_{yy} = .00454 - .14029(.01771) = .00206 \text{ IN}^4$$

$$Z_{yy} = \frac{.00206}{.2109} = .009767 \text{ IN}^3$$

BEAM "AD" STRESSES

$$f_b = M/Z$$

$$F_{ty} = 35,000 \text{ psi}$$

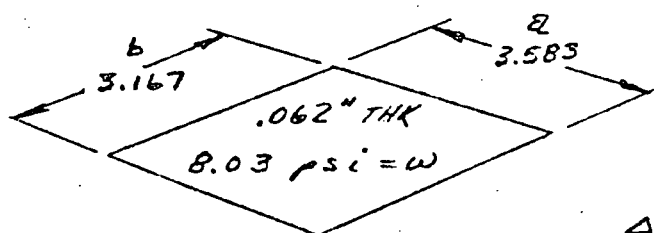
$$F_{tu} = 38,000$$

$$ULT = 1.5 \times LIM.$$

SECTION	MOMENT	Z-IN. ³	BENDING STRESS	M.S. LIM	M.S. ULT.
1	45.55 IN.LB.	.00254	17,930 psi	+.49	+.29
2	87.54	.0039	22,450	+.36	+.11
3	125.95	.00575	21,900	+.375	+.14
4	160.80	.00691	23,270	+.34	+.08
5	192.09	.00875	21,950	+.37	+.13
6	219.85	.01309	16,795	+.52	+.34
7*	227.24	.00977	23,260	+.34	+.08

* ESTIMATED MAX. MOMENT SECTION

THE PRECEDING SOMEWHAT CONSERVATIVE ANALYSIS REVEALS NO PROBLEMS STRUCTURALLY WITH THE LOWER ENCLOSURE PLATE. THE FIXIDY AT THE PLATE EDGE HAS BEEN IGNORED BECAUSE IT WILL BE SMALL AND WILL LOWER THE PRESSURE STRESSES. INCREASED ALLOWABLES FOR PLASTIC BENDING HAVE NOT BEEN USED. THEIR USE WOULD EFFECT EACH SECTION DIFFERENTLY BUT THE USE WOULD INCREASE ALL MARGINS OF SAFETY. RESONANT FREQUENCIES OF THE SMALL SUB PLATE AREAS FALL ABOVE 2000 CP. A PRESSURE CALCULATION IS SHOWN BELOW.



$$\alpha = \frac{3.167}{3.583} = .884$$

$$\alpha^3 = .691 \quad t^3 = .003844$$

$$b^2 = 10.03$$

FROM ROARKE 3RD ED. pg 203

$$f_b = \frac{.75 w b^2}{t^2(1 + 1.6/\alpha^3)} = 7440 \text{ psi} \quad @ \text{ CENTER}$$

$$\Delta = \frac{0.1422 w b^4}{Et^3(1 + 2.21\alpha^3)} \approx .018 \text{ IN.}$$

$$E = 10^7 \text{ psi}$$

CALCULATION OF PRESSURE AND ACCELERATION LOADS
ON ENCLOSURE SIDE PLATE.

THE TOTAL LOAD ON THE ENCLOSURE SIDES WILL BE CALCULATED IN A SIMILAR MANNER AS THOSE ON THE BOTTOM PLATE, THAT IS, THE ACCELEROMETER RMS LEVELS READ FROM THE 55g RMS RANDOM VIBRATION TEST WILL BE APPLIED TO THE TOTAL PLATE AREA TO CALCULATE AN EQUIVALENT PRESSURE WHICH WILL BE ADDED TO THE DESIGN PRESSURE DIRECTLY.

$$10 \text{ RMS g's} \quad 111.3 \times \frac{64}{55} = 129. \text{ g's}$$

36 PEAKS WILL GO TO 388. g's

UNIT AREA VIBRATION LOAD ON THE SIDE PLATE WILL BE.

$$.04 \times .098 \times 388. = 1.52 \text{ psi}$$

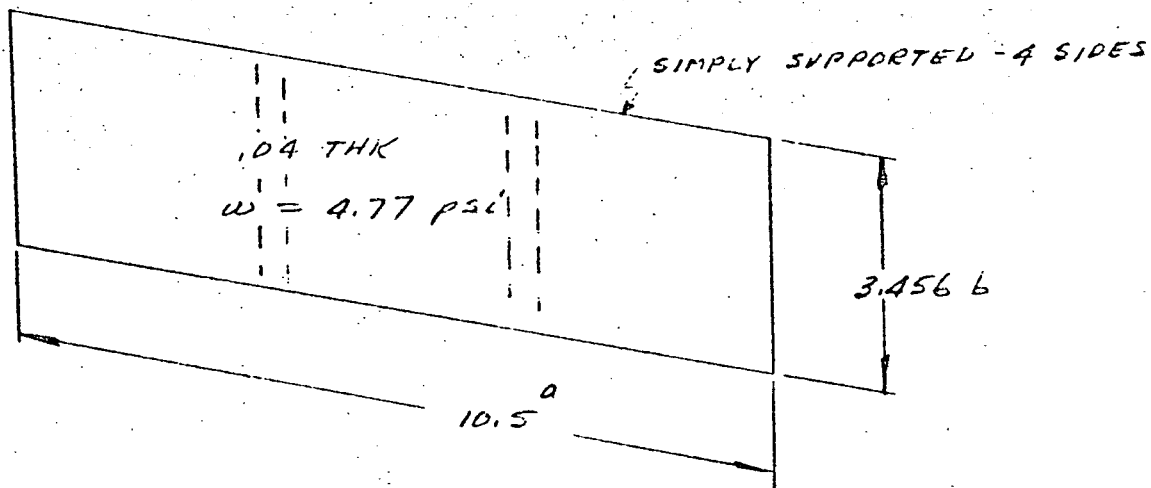
LIMIT DESIGN LOAD ON SIDE PLATE IS:

$$3.25 + 1.52 = 4.77 \text{ psi}$$

THE LARGEST SIDE WILL BE USED FOR THE ANALYSIS (10.5 X 3.456). A UNIFORM THICKNESS OF .04" WILL BE ASSUMED. THIS IGNORES STIFFENING RIBS AIDING IN PANEL SUPPORT. THE PANEL DEFLECTION IS EXPECTED TO BE LARGER THAN $\frac{1}{2}$ THICKNESS THEREFORE A DIAPHRAM ANALYSIS WILL BE USED. SEE ROARKE 3RD ED PG 222.

CALCULATION OF PRESSURE AND ACCELERATION
LOADS AND STRESSES ON ENCLOSE SIDE PLATE.

ROARKE 3RD ED. pg 222



$$t^2 = .0016$$

$$t^4 = .00000256$$

$$b^2 = 11.92$$

$$b^4 = 142.09$$

$$E = 10^7 \text{ psi}$$

$$a/b = 3.$$

$$Et^2/b^2 = \frac{10^7 \times .0016}{11.92} = 1.342 \times 10^3$$

$$\frac{wb^4}{Et^4} = \frac{4.77 \times 142.09}{10^7 \times .00000256} = \frac{677.8}{25.6} = 26.5$$

$$\eta/t = .946 + \frac{.06}{25}(1.24 - .946) = .962$$

$$\eta = .962 \times .04 = .038 \text{ in.}$$

$$\frac{s_b b^2}{Et^2} = 2.40 + .06(4.15 - 2.4) = 2.50$$

$$s_b = 1.342 \times 2.5 \times 10^3 = 3355 \text{ psi @ CENT}$$

$$\frac{s b^2}{Et^2} = 7.16 + .06(10.3 - 7.16) = 7.35$$

$$s = 1.342 \times 7.35 \times 10^3 = 9865 \text{ psi @ CE}$$

BY DGP DATE 10/18/71 SUBJECT E/P SENSOR SHEET NO. 10 OF
CHKD. BY DATE QUAL MODEL JOB NO.
 SIDE PLATE

LIMIT MS

$$M.S._{lim} = 1. - \frac{9865}{35000} = +.72$$

ULT MS

$$M.S._{ULT} = 1. - \frac{1.5 \times 9865}{38000} = +.61$$

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall DEPT./ BLDG./ PLANT/ DATE
ORON. 625-40 ZONE Beta FAC. HASD 1-14-72
EPS-855

FROM D. L. Vincent DEPT./ BLDG./ PLANT/ EXT.
ORON. 625-40 ZONE Beta FAC. HASD 422

SUBJECT: EPS Baseplate: Qualification Model

An analysis of the baseplate under combined pressure and random vibration was made ("Electron/Proton Sensor, Combined Pressure and Random Vibration, 10/18/71; D.G. Probe") based on 'R' Axis random vibration as specified in NAR's ICD.

It has now been proposed that the 'R' Axis random vibration criteria be:

Max. g and lift-off simulation - 80 secs.

20 -	175 Hz	+9 dB/oct increase	
175 -	350 Hz	6.0 g ² /Hz	
350 -	2000 Hz	-3 dB/oct decrease	(70.5 g rms)

Transonic/Mach I Simulation - 10 secs

20 -	175 Hz	+9 dB/oct increase	
175 -	350 Hz	10.0 g ² /Hz	
350 -	2000 Hz	-3 dB/oct decrease	(91.0 g rms)

It is therefore necessary to re-examine the integrity of the baseplate when subjected to the proposed vibration levels

Vibration Test level achieved, 55 g rms in 'R' Axis
monitored response on baseplate = 143 g rms.

Hence, rms vibration of baseplate at new level:

$$= 143 \times \frac{91}{55} = 236.6 \text{ g rms}$$

and peak level (3σ) will not exceed 3 x 236.6 = 709.8 g

From previous analysis:

Equiv. Unit Load @ 499.2 g = 4.78 lbs/sq. in.

Hence, Equiv. Unit Load @ 709.8 g =

$$4.78 \times \frac{709.8}{499.2} = 6.8 \text{ lbs/sq. in.}$$

and moment factor (vibration)

$$= \frac{6.8}{3.25} = 2.092$$

Again, from previous analysis, maximum pressure moment is 92 lbs-ins @ section 7.

Max. vibration moment = $92 \times 2.092 = 192.46$ lbs-ins
Section modulus, section 7 = .00977

$$f_b = \frac{M}{Z} \quad F_{Oy} = 35,000 \text{ PSI} \quad F_{Ou} = 42,000 \text{ PSI}$$

$$f_b = \frac{192.46}{.00977} = 19,699 \text{ PSI}$$

$$F \text{ of } S_{Lim.} = \frac{35,000}{19,699} = 1.78 \quad M.S._{Lim} = +.78$$

$$F \text{ of } S_{Ult.} = \frac{42,000}{1.5 \times 19,699} = 1.42 \quad M.S._{Ult} = +.42$$

The above values are based on vibration only, as when the baseplate is subjected to qualification testing.

Consider with 3.25 PSI pressure added, then:

$$f_b = \frac{192.46 + 92}{.00977} = 29,116 \text{ PSI}$$

$$F \text{ of } S_{Lim} = \frac{35,000}{29,116} = 1.20 \quad M.S._{Lim} = +.20$$

$$F \text{ of } S_{Ult} = \frac{42,000}{1.5 \times 29,116} = .96 \quad M.S._{Ult} = -.04$$

These figures indicate that the baseplate is marginal when subjected to the proposed peak vibration and pressure levels, but appears to present no problems if subjected to the vibration levels only.

The preceding is a somewhat conservative analysis, as was the analysis previously prepared. The notes on P. 15 of D. G. Probe's analysis apply here also.

The calculations show that the baseplate will meet the new vibration levels in qualification testing, if imposed. However, there is no real margin of safety for the combined pressure and vibration condition. Considering the increase in the vibration level, this is not surprising.

Failure of the baseplate, should it occur, would not be dramatic, but would probably consist of some cracking in the region of section 4 and/or 7.

IT HAS BEEN PROPOSED TO RAISE THE EPS QUALIFICATION RANDOM VIBRATION CRITERIA TO :-

MAX. 9 AND L.F.T.-OFF SIMULATION.

20-175 Hz	+9dB/OCTAVE	
175-350 Hz	6.0 g ² /Hz	
350-2000 Hz	-3dB/OCTAVE	(70.5g r.m.s.)

TRANSONIC/MACH1 SIMULATION.

20-175 Hz	+9dB/OCTAVE	
175-350 Hz	10.0 g ² /Hz	
350-2000 Hz	-3dB/OCTAVE	(91.0 g r.m.s.)

IT IS THEREFORE NECESSARY TO RE-EXAMINE THE BASEPLATE, OUTER HOUSING AND THE RESPONSE OF THE VIBRATION ISOLATORS TO THIS INCREASE IN RANDOM VIBRATION LEVELS.

AN ANALYSIS OF THE BASEPLATE UNDER COMBINED DIFFERENTIAL PRESSURE AND RANDOM VIBRATION WAS MADE (ELECTRON/PROTON SENSOR, COMBINED PRESSURE AND RANDOM VIBRATION, 10/18/71, D.G. PROBE) BASED ON THE 'R' AXIS RANDOM VIBRATION AS SPECIFIED IN N.A.R'S I.C.D. THE FOLLOWING PAGES UP-DATE THAT ANALYSIS TO APPLY TO THE NEW VIBRATION CRITERIA.

STRUCTURAL TEST UNIT, 'R' AXIS RANDOM VIBRATION:-

RANDOM VIBRATION TEST INPUT = 55.0g r.m.s.

BASEPLATE RESPONSE = 143g r.m.s.

BASEPLATE RESPONSE AT 21.0g r.m.s = $143.0 \times \frac{21}{55} = 236.6g$.

AT PEAK LEVEL (3σ), RESPONSE WILL NOT EXCEED
 $3 \times 236.6 = 709.8g$.

WEIGHT OF BASEPLATE = .93 LBS.

EQUIVALENT TOTAL LOAD ON BASEPLATE = $709.8 \times .93 = 660.114$.

$$= \frac{660.114}{10.5 \times 9.25} = 6.797 \text{ LBS/SQ. IN.}$$

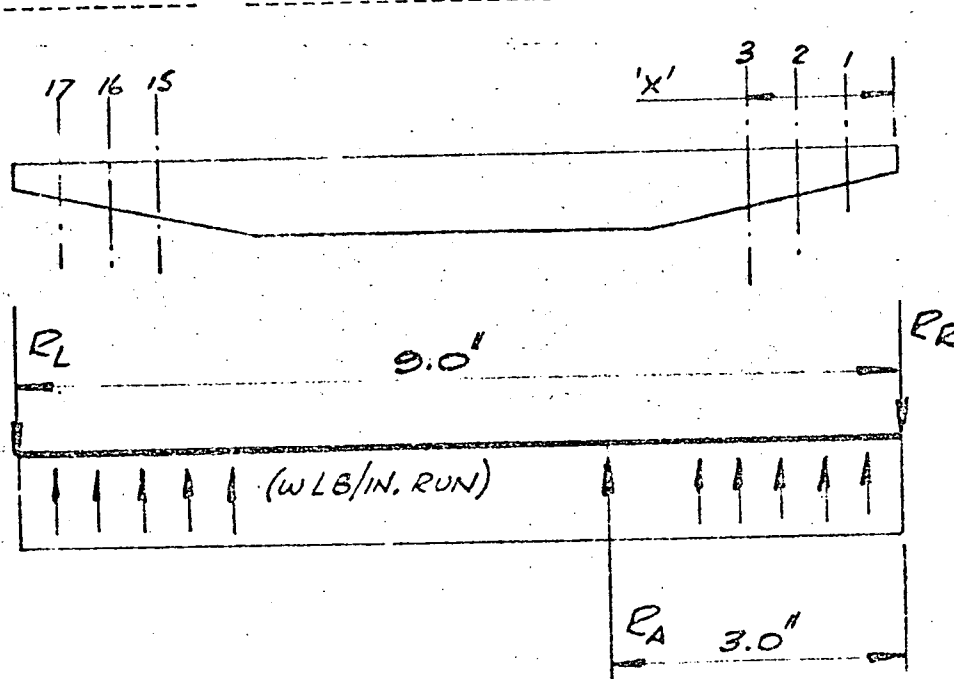
INCLUDING 3.25 P.S.I. PRESSURE DIFFERENTIAL,
 TOTAL PRESSURE EQUIVALENT = $6.8 + 3.25$
 $= 10.05 \text{ LB./SQ. IN.}$

FROM PREVIOUS ANALYSIS, BEAM AD IS CRITICAL BEAM,
 AND DISTRIBUTED LOAD ON BEAM WAS 5.77 LB/IN. FOR
 3.25 LB/SQ. IN. PRESSURE, AND R_A WAS 17.76 LB.

UNDER NEW LOADING, DISTRIBUTED LOAD

$$w = 5.77 \times \frac{10.05}{3.25} = 17.84 \text{ LB/IN.}$$

$$\text{AND } R_A = 17.76 \times \frac{10.05}{3.25} = 54.92 \text{ LB.}$$



SECTIONS TAKEN
 EVERY .5' ALONG
 LENGTH OF BEAM.

$$w = 17.84 \text{ LB/IN.}, R_A = 54.92 \text{ LB.}$$

$$R_R = \left[\frac{\left(\frac{17.84 \times 9 \times 9}{2} \right) + (54.92 \times 6)}{9} \right] = \left[\frac{722.52 + 329.52}{9} \right]$$

$$= 116.89 \text{ LB.}$$

$$\text{AND } R_L = 54.92 + (17.84 \times 9) - 116.89 = 98.59 \text{ LB.}$$

TO DETERMINE BENDING MOMENT AT STATIONS EVERY .5' ALONG BEAM :-

WHEN 'X' LIES BETWEEN R_R AND R_A ,
 BENDING MOMENT, $M = R_R x - \frac{wx^2}{2}$

WHEN 'X' LIES BETWEEN R_A AND R_L ,

$$M = R_R x - \frac{wx^2}{2} - R_A (x - 3.0)$$

$$R_e = 116.89, \omega = 17.84, R_A = 54.92$$

STATION	'X'	$R_e X$	X^2	$\frac{\omega X^2}{2}$	$X-3$	$R_A(X-3)$	M
0	0	0	0	0	—	—	0
1	.5	58.445	.25	2.23	—	—	56.215
2	1.0	116.89	1.00	8.92	—	—	107.97
3	1.5	175.335	2.25	20.07	—	—	155.265
4	2.0	233.78	4.00	35.68	—	—	198.10
5	2.5	292.225	6.25	55.75	—	—	236.475
6	3.0	330.67	9.00	80.28	0	0	270.39
7	3.5	409.115	12.25	109.27	.5	27.46	272.385
8	4.0	467.56	16.00	142.72	1.0	54.92	269.92
9	4.5	526.005	20.25	180.63	1.5	82.38	262.995
10	5.0	584.45	25.00	223.00	2.0	109.84	251.61
11	5.5	642.895	30.25	269.83	2.5	137.30	235.765
12	6.0	701.34	36.00	321.12	3.0	164.76	215.46
13	6.5	759.785	42.25	376.87	3.5	192.22	190.695
14	7.0	818.23	49.00	437.08	4.0	219.68	161.47
15	7.5	876.675	56.25	501.75	4.5	247.14	127.785
16	8.0	935.12	64.00	570.88	5.0	274.60	89.64
17	8.5	993.565	72.25	644.47	5.5	302.06	47.035
18	9.0	1052.01	81.00	722.52	6.0	329.52	-.03

MAX. M = 272.391 OCCURS AT X = 3.473"

TABLE OF BENDING MOMENTS.

STATION	MOMENT LBS-INS.	I INS ⁴	Z INS ³	STRESS LB/SQ. IN.
1	56.215	.00036	.00254	20,557
2	107.97	.00034	.0039	27,685
3	155.265	.00085	.00575	27,003
4	198.100	.00121	.00691	28,669
5	236.475	.00176	.00875	27,026
6	270.39	.00287	.01309	20,656
7	272.385	.00206	.009767	27,888
8	269.92	.00206	.009767	27,636
9	262.995	.00206	.009767	26,927
10	251.61	.00206	.009767	25,761
11	235.765	.00206	.009767	24,139
12	215.46	.00287	.01309	16,460
13	190.695	.00176	.00875	21,794
14	161.47	.00121	.00691	23,368
15	127.785	.00085	.00575	22,223
16	89.64	.00054	.0039	22,215
17	47.035	.00036	.00254	18,518

* POINT OF MAX. STRESS IN BEAM.

TABLE OF BENDING STRESS.

MAX. BENDING STRESS = 28,669 LB/SQ. IN.

BEAM MATL. — ALUM. ALLOY, 6061-T6.

$F_{ty} = 35,000 \text{ LB/SQ. IN.}$

$F_{tx} = 42,000 \text{ LB/SQ. IN.}$

FACTOR OF SAFETY :-

$$F.S._{LIM.} = \frac{35000}{28669} = 1.22$$

$$\therefore M.S._{LIM} = +.22$$

$$F.S._{ULT.} = \frac{42000}{1.5 \times 28669} = .977$$

$$\therefore M.S._{ULT.} = -.023$$

AT EDGES OF BEAM, BENDING STRESS IS COMBINED WITH BENDING STRESS INDUCED IN PANELS. MAXIMUM COMBINATION IS AT STN. 3.

$$\text{BENDING STRESS (BEAM)} = 27,003 \text{ LB/SQ. IN.}$$

ASSUME PANEL 2.75 SQUARE.

$$t = .063 \quad \frac{a}{b} = 1.0$$

(Roark, Table 10, case 41)

$$S_b = \frac{\beta w b^2}{t^2} \quad \beta = .3078, \quad w = 10.05 \text{ P.S.I.}$$

$$= \frac{.3078 \times 10.05 \times 2.75^2}{.063^2}$$

$$= 5894 \text{ LB/SQ. IN.}$$

$$\text{COMBINED STRESS} = \frac{27003 - (-5894)}{2} = 16,449 \text{ LB/SQ. IN.}$$

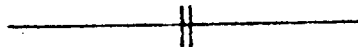
$$\text{FOR 6061-T6, } F_{s,u} = 27,000 \text{ LB/SQ. IN. } F_{s,y} = 20,000 \text{ LB/SQ. IN.}$$

$$F.S. \text{ LIM} = \frac{20,000}{16,449} = 1.216$$

$$M.S. \text{ LIM} = +.216$$

$$F.S. \text{ ULT.} = \frac{27000}{1.5 \times 16449} = 1.09$$

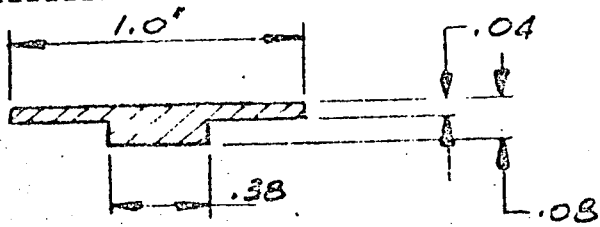
$$M.S. \text{ ULT.} = +.09$$



CONSIDER EFFECT OF BASEPLATE BENDING ON ELECTRON BEAM WELD AROUND EDGE.

$$\text{MAX. SLOPE AT END OF BEAM} = .058 \text{ RADIANS.}$$

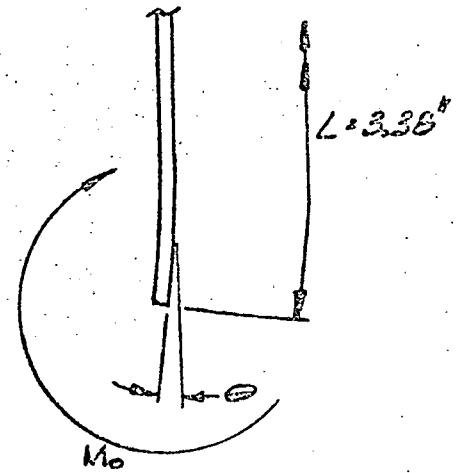
CONSIDER SIDE RIB AS CANTILEVER BEAM UNDER END MOMENT.



RIB SECTION

$$I = .00002845 \text{ INS.}^4$$

$$Z = .000553 \text{ INS.}^3$$



$$\theta = \frac{M_o L}{EI}$$

$$\therefore M_o = \frac{\theta EI}{L} = \frac{.058 \times 10 \times 10^6 \times 28.45 \times 10^{-6}}{3.38}$$

$$= 4.48 \text{ LB-INS.}$$

$$\text{AND } \frac{M_o}{Z} = \frac{4.48}{.000553} = 8,128 \text{ LB/SQ.IN. IN RIB.}$$

STRESS IN WELD:-

$$\text{ASSUME LENGTH OF WELD} = 1.5 \times .38 = .57''$$

$$\text{THEN STRESS IN WELD DUE TO BENDING}$$

$$= \frac{6 M}{b t^2} = \frac{6 \times 4.48}{.57 \times .08^2} = 7,368 \text{ LB/SQ.IN.}$$

$$\text{TOTAL STRESS IN WELD} = \frac{.93 \times 709.8}{39.5 \times .08} + 7,368 = 209 + 7,368$$

$$= 7,577 \text{ LB/SQ.IN.}$$

INTERDEPARTMENTAL COMMUNICATION

10

B. C. Hall

DEPT./ 625-40 Bldg./ Beta PLANT/ HASD DATE 2-8-72
ORGN. 2093 FAC. EPS-675

FROM

D. L. Vincent

DEPT./ 625-40 Bldg./ Beta PLANT/ HASD EXT. 422
ORGN. 2093 FAC.

SUBJECT: Proposed Increase in Qualification Vibration Levels for
the EPS

It has been proposed to increase the EPS 'R' axis qualification
random vibration criteria from:

Max g and Lift-off Simulation 80 seconds
20 - 125 Hz @ 12 dB/Oct Increasing
125 - 500 Hz - 2.0 g^2 /Hz
500 - 675 Hz - -9 dB/Oct
675 - 1100 Hz - .80 g^2 /Hz
1100 - 2000 Hz - -9 dB/Oct (overall - 41 g rms)

Transonic/MACH 1 Simulation 10 seconds
20 - 125 Hz @ 12 dB/Octave increasing
125 - 500 Hz - 5.0 g^2 /Hz
500 - 675 Hz - -9 dB/Octave
675 - 1100 Hz - 2.0 g^2 /Hz
1100 - 2000 Hz - -9 dB/Octave (overall = 64 g rms)

to the following levels:

Max. g and Lift-off Simulation 80 seconds
20 - 175 Hz - +9 dB/Octave
175 - 350 Hz - 6.0 g^2 /Hz
350 - 200 Hz - -3 dB/Octave (overall = 70.5 g rms)

Transonic/MACH 1 Simulation 10 seconds
20 - 175 Hz - +9 dB/Octave
175 - 350 Hz - 10.0 g^2 /Hz
350 - 2000 Hz - -3 dB/Octave (overall - 91.0 g rms)

Test time has not been changed.

These new levels represent a considerable increase in the vibration input to the EPS in the 'R' axis, which has always been the most severe axis for vibration response.

The effect of the proposed levels on an EPS test unit was considered in two ways:

1. What increase in vibration response and stress levels would be seen on the hard-mounted outer housing?
2. What increase in vibration input would the electronics package receive from the vibration isolators?

From the EPS Structural Test Unit results, we know that the baseplate is probably the most highly stressed part in the unit. A prior stress analysis was undertaken to verify the integrity of the baseplate under combined pressure and random vibration. This analysis has been updated to reflect the new vibration levels, and both are included as attachments to this memo.

These analyses are hand calculated. A number of assumptions have been made in them, and these assumptions probably err on the side of conservatism in the approach, but not necessarily so. It is usual in such cases to apply a factor of safety to such hand-calculated results. No such factors of safety have been used in the accompanying analyses.

The analysis of the baseplate shows that its integrity under a combination 3.25 p.s.i. differential pressure and the proposed transonic/Mach 1 simulation random vibration cannot be verified. Stresses at several sections are too high, and in one case we have a negative margin of safety occurring on ultimate loading. While the stress levels would be about 30% lower for the random vibration criteria alone, no account has been taken of potential stress concentration areas - of which the baseplate has several.


It should perhaps be mentioned that if the initial design and stress check had been performed using the presently proposed vibration criteria, the resulting baseplate would not be to the present configuration. It would be stronger, stiffer and probably 20 - 25 % heavier.

Investigation of the response of the vibration isolators to the proposed vibration levels gives a new input level of 6.75 g rms compared to 6.1 g rms for the old, and a deflection

requirement of .127" compared to .115". These are based on hand calculations by the writer.

Barry Controls, manufacturers of the vibration isolators, have carried out a computer analysis of the isolator response to the new levels which confirms these hand calculations.

Obviously, the response levels of the electronics components will increase over the response to the previous level, but not excessively so and will probably not be critical.


D. L. Vincent

VIBRATION ISOLATOR RESPONSE
(BARRY CONTROLS ANALYSIS)

'R' Axis

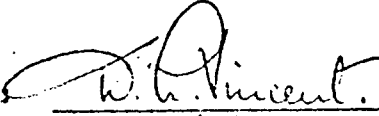
Max. g and Lift-off.

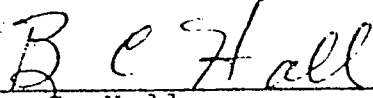
	3 Sigma RMS (g's)	3 Sigma RMS Displ. (inches)
35 Hz	12.10 (7.47)	.084" (.051)
50 Hz	23.20 (15.57)	.085" (.059)
Transonic/MACH 1		
35 Hz	15.6 (11.79)	.110" (.0804)
50 Hz	29.9 (24.63)	.110" (.0882)

Note: Values in parenthesis are for previous test criteria.

REPORT: COMPARISON OF ACCELERATION LEVELS TO
OTHER DYNAMIC TEST LEVELS FOR THE
ELECTRON-PROTON SPECTROMETER

LEC Document Number EPS-592

Prepared by: 
D. L. Vincent
Mech. Engineer

Approved by: 
B. C. Hall
Program Manager

COMPARISON OF ACCELERATION LEVELS TO OTHER DYNAMIC TEST LEVELS FOR THE ELECTRON-PROTON SPECTROMETER

Preface

At the Critical Design Review of the Electron-Proton Spectrometer (EPS) held 19th - 20th October 1971, the absence of any acceleration testing for the EPS caused concern to some participants. As a result of this concern, RID T-4 was generated requiring that LEC do an analysis to verify the integrity of the EPS to a 'qualification' level of acceleration and compare this with other dynamic test levels. This report has been written to comply with this requirement.

Introduction

The boost acceleration occurs only in the +X direction of the EPS and reaches a peak value of 4.9 g, hence an ultimate 'qualification' test level would be $4.9 \times 1.5 = 7.35$ g.

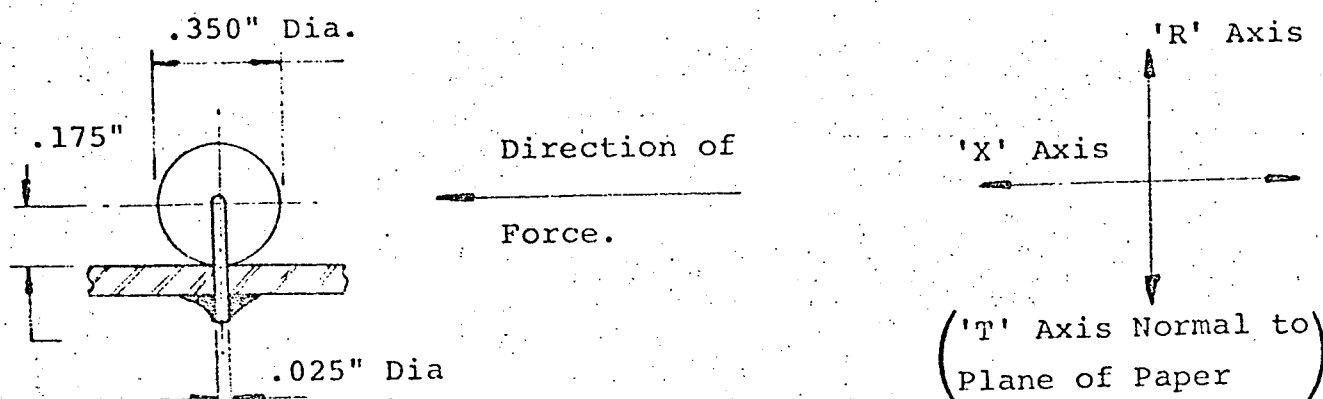
A 20 g, 11 millisecond terminal sawtooth basic design shock and qualification level random vibration test has already been carried out on the EPS Structural and Engineering Test Units. The attached figure shows that, in the 'X' axis, both these tests expose the EPS to higher 'g' levels than the proposed acceleration level. Additionally, the response of the EPS electronic package upon its vibration isolators exceeds this proposed acceleration level between the range of 30 - 80 cps.

Consideration of the type of loading induced by each of the test methods assists in an evaluation of the relative severity of each of the tests. Acceleration will produce in the EPS and its component parts a unidirectional steady state load; failure will occur when this load exceeds the ultimate load that the part can withstand. Shock also produces an essentially unidirectional force, suddenly applied and of short duration. Shock induces loading which has approximately twice the effect of the same 'g' loading steadily applied. In this instance failure could occur at a level substantially below that causing a failure in an acceleration mode. Random vibration produces a continually varying bi-directional force which produces an alternating load of varying magnitude; failure can occur from overloading the component or from fatigue. A component can fatigue at a substantially lower loading than that required for failure under steady state conditions.

Hence, it can be seen that for an equal load situation, both vibration and shock are more severe than acceleration. On this basis, an analysis was made of the stress levels induced by the various test conditions in the leads of a typical EPS component. The factors of safety for each test mode were then compared.

Analysis

One of the largest and heaviest components in the EPS electronics package is the Kemet Capacitor, T210D156K075PS, mounted on the input filter printed circuit board of the filter module. This component is taken as being representative of those components in the EPS electronics package.



Component Data:

Weight = 6.3 grams (.014 lbs)

Lead Material = Tinned Nickel Wire

Ultimate Tensile Strength = 70,000 lbs/sq. ins.

Yield Strength = 40,000 lbs/sq. ins.

Endurance Limit = 28,000 lbs/sq. ins.

$$\text{Lead Section Modulus, } Z = \frac{\pi D^3}{32} \times 2 = \frac{2\pi \times .025^3}{32} = .307 \times 10^{-5} \text{ ins}^3 \text{ (for two leads)}$$

(for conservative analysis, the supporting effect of conformal coating will be ignored.)

Acceleration

Acceleration force = 7.35 g

Induced load = 7.35 x .014 = .103 lbs

Bending moment on leads, M = .103 x .175 = .018 lbs - ins.

$$\text{Bending stress} = \frac{M}{Z} = \frac{.018}{.307 \times 10^{-5}} = 5,863 \text{ lbs./sq. ins.}$$

$$\text{Factor of Safety} = \frac{\text{U.T.S.}}{\text{Bending Stress}} = \frac{70,000}{5,863} = 11.9$$

Random Vibration

R.M.S. input to electronics package = 4.46

Induced load = $4.46 \times .014 = .062 \text{ lbs.}$

Bending moment on leads, $M = .062 \times .175 = .011 \text{ lbs-ins.}$

$$\text{Bending stress} = \frac{.011}{.307 \times 10^{-5}} = 3583 \text{ lbs/sq. ins.}$$

$$\text{Factor of Safety} = \frac{\text{Endurance Limit}}{\text{Bending Stress}} = \frac{28,000}{3,583} = 7.8$$

(The above is based on the rms level. At this level, 7.35 g will be exceeded approximately 10% of the time.)

Shock

Shock input to electronics package = 24 g.

Induced load = $2 \times 24 \times .014 = .672 \text{ lbs.}$

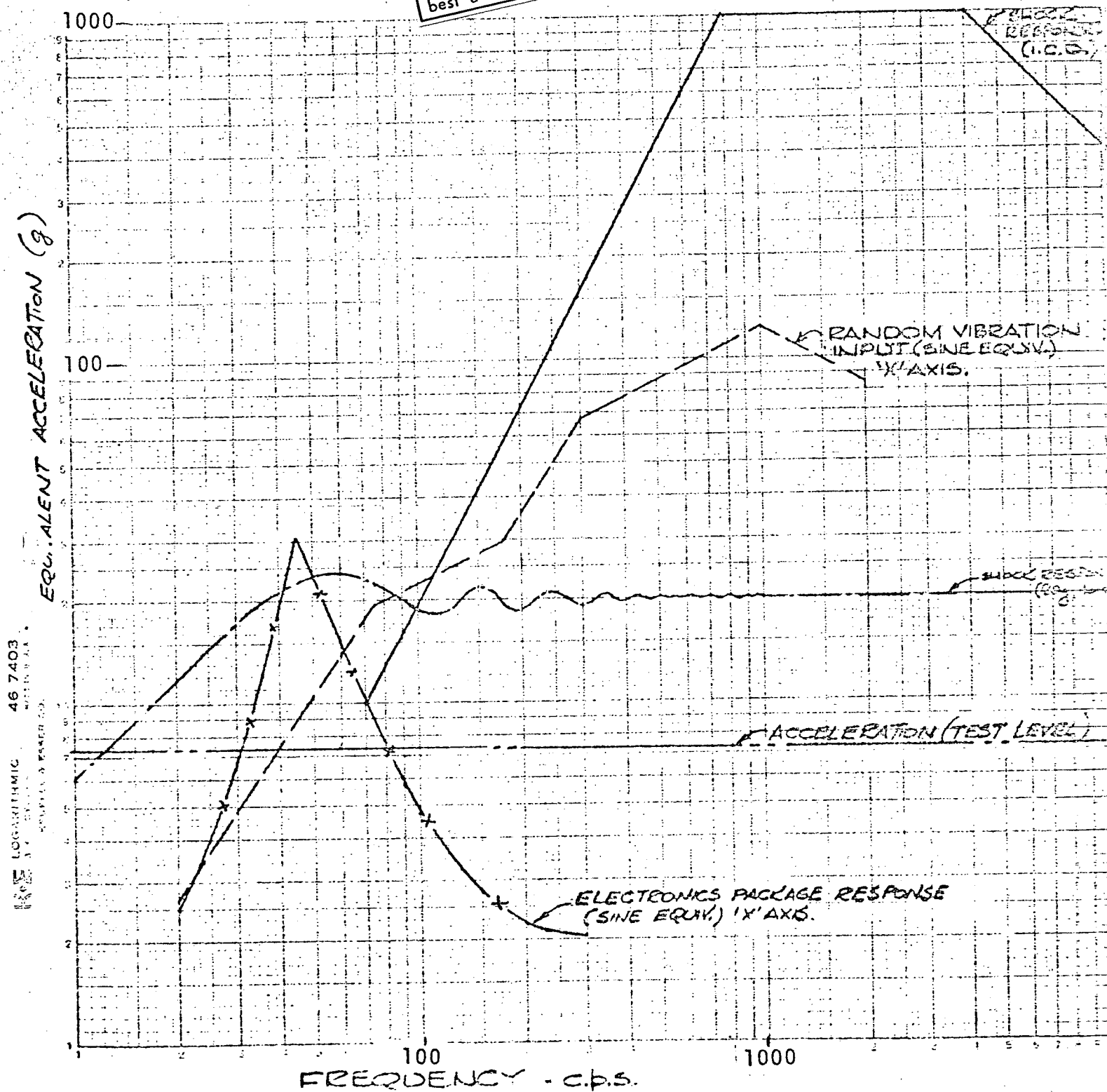
Bending moment on leads, $M = .672 \times .175 = .118 \text{ lbs-ins.}$

$$\text{Bending stress} = \frac{.118}{.307 \times 10^{-5}} = 38,436 \text{ lbs-ins.}$$

$$\text{Factor of Safety} = \frac{\text{U.T.S.}}{\text{Bending Stress}} = \frac{70,000}{38,436} = 1.82$$

Conclusions

It can be seen that both the random vibration and shock requirements exceed the acceleration test level by a considerable margin, even for the electronics package. The factors of safety compared to the failure level are lower for these two tests than for acceleration. It is therefore considered that these two tests adequately validate the ability of the EPS to meet the boost acceleration levels and an acceleration environment of 7.35 g.



STATEMENT OF WORK
BARRY VIBRATION ISOLATORS FOR EPS

It is required that the vibration isolator design provided by the Barry Division of Barry Wright Corp. to LEC Procurement Specification EPS-356 be analyzed for the following proposed change in the 'R' Axis Random Vibration Environment:

Max. g and Lift Off Simulation

20 - 175 Hz	+9 dB/octave increase
175 - 350 Hz	6.0 g ² /Hz
350 - 2000 Hz	-3 dB/octave decrease

duration - 80 seconds.

Transonic/MACH 1 Simulation

20 - 175 Hz	+9 dB/octave increase
175 - 350 Hz	10.0 g ² /Hz
350 - 2000 Hz	-3 dB/octave decrease

duration - 10 seconds.

The analysis shall compare the 3 sigma rms acceleration and the 3 sigma rms deflection responses of the isolator for the above vibration levels with those levels given for the 'R' axis in EPS-356. Also investigate the possibility of the isolator "Bottoming Out" under the proposed vibration levels.

Additionally, provide an isolator response curve for the transonic/MACH 1 simulation and advise whether any standing wave effects can be anticipated.

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./ 625-40 EDCO./ Beta PLANT/ HASD RATE 3-21-72
OCCN. 12043

EPS-722

FROM D. L. Vincent

DEPT./ 625-40 EDCO./ Beta PLANT/ HASD EXT. 422
OCCN. 12043

SUBJECT: Vibration Testing of the EPS Electronics

At the CDR a request for the acceptance testing of the EPS electronics by random vibration without isolators was disallowed. However, since that time, Boeing has taken over the G. E. support contract in reliability, etc., and while discussing the results of the qualification vibration testing with their representative, Mr. Dick Lopez, it became increasingly obvious that a move is afoot to have the EPS electronics tested to an acceptance random vibration level without the isolators, etc. Mr. A. J. Farkas is aware of this move.

It is presumed that such a test would be run to the levels originally given, i.e. 20 - 80 Hz, +3 dB/oct.: 80 - 350 Hz, .04 g²/Hz: 350 - 2000 Hz, -3 dB/oct., a composite level of 6.3 g rms. However, the qualification unit would have to be qualified at a higher level (.067g²/Hz at 80 - 350 Hz) giving a composite level of 9.8 g rms.


To perform such a test would require the manufacture of an adapter for the vibration test fixture by BRN, and also a solid adapter to replace the isolators on the mounting straps, so that the electronics unit could be mounted to the fixture for testing.

Some problems associated with such a test are:

- 1) The qualification test level is higher than that seen by the electronics unit in response to the high energy level in the full-blown qualification test.
- 2) The eccentric loading on the mounting straps will be approximately 50% higher than they were designed for, hence their integrity should be investigated.
- 3) With the unit hard mounted to the fixture, the transmissibility of the interface will change, and the response of the electronics will be considerably higher compared to when it is mounted on isolators. Additionally the peak input will be at a much higher frequency than previously experienced.

- 4) From 3), it follows that the electronics components would experience random vibration levels well in excess of those they have experienced mounted on the isolators.

The above is written to provide some idea of the impact of such a test, should a request to comply with such a requirement be forthcoming.


D. L. Vincent

cc: B. E. Curtsinger

ELECTRON-PROTON SPECTROMETER

COMBINED PRESSURE & RANDOM VIBRATION

THE STRUCTURAL INTEGRITY OF THE EPS HARDWARE HAS BEEN DEMONSTRATED BY THE QUALIFICATION TESTING. VISUAL AND X-RAY EXAMINATION OF THE OUTER HOUSING AND BASEPLATE SHOW NO CRACKING OR OTHER EVIDENCE OF FAILURE.

PRIOR ANALYSIS OF THE BASEPLATE (D.G. PROBE, 10-18-72) AND UPDATE OF THIS ANALYSIS (D.L. VINCENT, 1-14-72) INDICATE THAT THE BASEPLATE WAS MARGINAL UNDER THE COMBINED RANDOM VIBRATION AND PRESSURE CRITERIA. THESE ANALYSES WERE BASED ON AN ADMITTEDLY CONSERVATIVE APPROACH (SEE P.15 OF D.G. PROBE'S ANALYSIS).

THE ANALYSIS CAN NOW BE UPDATED & REFINED, UTILIZING DATA FROM THE ACCELEROMETER MOUNTED ON THE CRITICAL AREA OF THE BASEPLATE. ADDITIONALLY, THE HIGHER THAN ANTICIPATED VIBRATION RESPONSE ON THE BASEPLATE JUSTIFIES UTILIZING MORE OF THE SUB-PLATE IN THE CALCULATION OF THE SECTION PROPERTIES OF THE CRITICAL BEAM.

FROM QUAL. TEST INSTRUMENTATION

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CRITICAL BEAM RESPONSE = 496 g r.m.s. [For 108.4 g r.m.s. INPUT]

PRACTICAL TEST DATA HAS SHOWN THAT THE PEAK g LOAD RELATIVE TO THE g r.m.s. LEVEL FOR A RESPONSE ACCELEROMETER IS $1.6 \times g$ r.m.s., AND THIS IS APPLICABLE TO THE RESPONSE WHEN THE INPUT IS CLIPPED AT A 3 SIGMA PEAK AS IS THE CASE FOR THE QUAL. TEST.

FROM THIS IT FOLLOWS THAT PEAK g LEVEL FOR CRITICAL BEAM = $1.6 \times 496 = 793.6 g$.

WT. OF BASEPLATE = .93 lb

$$\text{UNIT LOAD} = \frac{.93 \times 793.6}{10.5 \times 3.25} = 7.599 \text{ LBS/SQ. IN.}$$

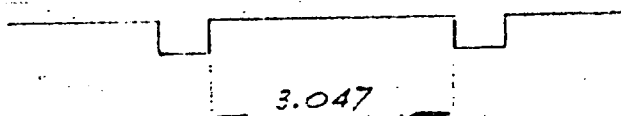
$$\text{PRESSURE FACTOR} = \frac{7.599}{3.25} = 2.338$$

∴ IF THE BENDING MOMENT DUE TO PRESSURE IS MULTIPLIED BY 2.338, THIS WILL GIVE MOMENT DUE TO COMBINED VIBRATION AND PRESSURE.

MAX. MOMENT DUE TO PRESSURE ONLY = 92 lbs.-ins.

COMBINED MAX. BENDING MOMENT = $92 \times 2.338 = 307.1 \text{ lbs.-ins.}$

THIS OCCURS AT SECTION 7 OF BEAM



(LENGTH OF BEAM = 9.17")

BEAM & PANEL SPACING.

THE EFFECTIVE WIDTH b' OF THE PLATE IS NEEDED.

FROM ROARK, 'FORMULAE FOR STRESS & STRAIN', 4TH ED., ARTICLE 37 :-

LET l = BEAM LENGTH

b = FLANGE WIDTH

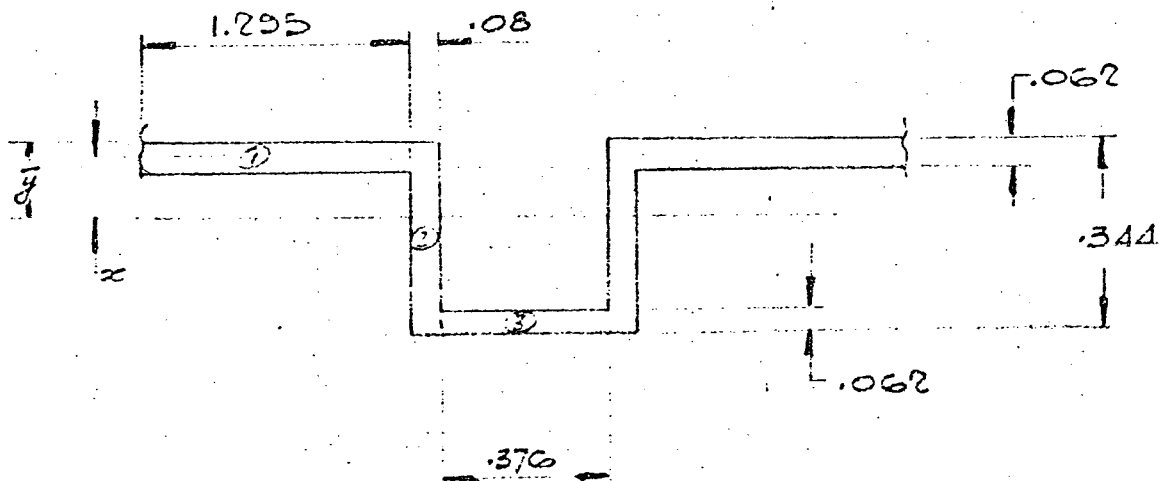
b' = EFFECTIVE WIDTH

$$\text{WHEN } \frac{l}{b} = \frac{9.17}{3.047} = 3.009 \approx 3.00$$

THEN $\frac{b'}{b} = .85$, SO THAT TOTAL EFFECTIVE WIDTH OF

$$\text{FLANGE} = .85 \times 3.047 = 2.59''$$

HENCE, SECTION 7 :-



SECT.	AREA A	y	Ay	$I_{CENTRAL}$	x	Ax^2	$I_{N.A.}$
1	.16058	.031	.004978	.0000514	.060	.000578	.0006294
2	.05504	.172	.009467	.000542	.081	.000381	.0009030
3	.02331	.313	.007296	.0000075	.222	.001149	.0011565
TOTAL	.23893		.021741	.0006007		.002088	.0026889

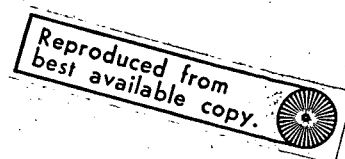
$$\bar{y} = \frac{.021741}{.23893} = .091''$$

$$I_{N.A.} = .0006007 + .002088 = .0026889 \text{ IN}^4$$

$$Z_{N.A.} = \frac{.0026889}{.253} = .01063 \text{ IN}^3$$

MAX. STRESS DUE TO COMBINED PRESSURE & VIBRATION:-

$$f_b = \frac{307.1}{.01063} = 28,890 \text{ LBS/SQ.IN.}$$



SO THAT:-

$$F.S._{LIMIT} = \frac{35,000}{28,890} = 1.21$$

AND MARGIN OF SAFETY = +.21

$$F.S._{ULT.} = \frac{42,000}{1.5 \times 28,890} = .97$$

AND MARGIN OF SAFETY = -.03

MAX. STRESS DUE TO VIBRATION ONLY:-

$$f_b = \frac{307.1 - 92}{.01063} = 20,235 \text{ LBS/SQ.IN.}$$

SO THAT:-

$$F.S._{LIMIT} = \frac{35,000}{20,235} = 1.73$$

AND M.S. LIMIT = +.73

$$F.S._{ULT.} = \frac{42,000}{1.5 \times 20,235} = 1.38$$

M.S. ULT. = +.38

THE ABOVE ANALYSIS STILL SHOWS A NEGATIVE MARGIN OF SAFETY ON AN ULTIMATE LOAD CONDITION. HOWEVER, BY USING THE ACTUAL QUAL. TEST RESULTS IN THE ANALYSIS (WHICH REFLECT AN OVERTEST CONDITION) COMBINED WITH THE DIFFERENTIAL PRESSURE (WHICH IS AT 3.25 P.S.I FOR A VERY SHORT DURATION) COUPLED WITH THE INHERENT CONSERVATISM OF TREATING THE BEAM AS SIMPLY SUPPORTED, THE ABOVE MARGINS OF SAFETY ARE LOWER THAN EXIST IN PRACTISE.

SUBJECT: Vibration Test Report (Interim) on Solid State Radiation Inc's Lithium Ion Drift Detectors

Introduction:

Arrangements were made to subject the SSR detectors, of the type to be used in the EPS experiment, to several random vibration spectra representative of those given for the MDA and OWS in document MSC-01159, Rev. C, "Flight Hardware Environmental Design Requirements". Sample detectors were taken to Building 15, NASA/ MSC for testing on 12-2-70. The vibration spectra to be used were selected, in conjunction with Mr. A. Farkas (NASA/ MSC), from the above mentioned document. It was intended that if the detectors survived these tests, the spectra would be increased in severity until a failure occurred, in an attempt to determine a maximum acceptable level of vibration.

Testing

The initial spectra selected are given in Appendix A. A diagram of a typical detector is shown in Figure 1. Two detectors, one of 2 mm size cube and the other of 3 mm (Nos. 021 and 076 respectively) were cemented with Eastman 910 adhesive to a test plate. The leads from the header entered clearance holes in the plate. This plate was then mounted to the shake table so that the detectors would be vibrated in the X axis. The random vibration spectrum for Zone 11 on the MDA was then run. After examining the detectors, the test plate orientation was changed to the Y axis, and the test repeated. Again the detectors were examined, and then the orientation was changed to the Z axis and the test repeated. The results of this series of tests are recorded at the end of this report.

At this point in time, two more detectors were cemented to the test plate, again one 2 mm and one 3 mm (Nos. 022 and 048 respectively).

Difficulty was experienced in setting up the OWS spectrum on the test equipment. Finally, the cause of the difficulty was isolated to the cooling system for the equipment. This was apparently running hot, causing the system to overheat and cut out. No further testing could be undertaken that day (12-2-70).

The LEC engineer arrived at the test area at 9 A.M. on 12-3-70 to find that the test equipment was still out of commission. He left his phone number, so that he could be advised when the test could be recommenced.

Results

The results of the testing was as follows:

MDA Spectrum

<u>Detector No.</u>	<u>021</u>	<u>076</u>
"X" Axis	No visible damage	No visible damage
"Y" Axis	No visible damage	No visible damage
"Z" Axis	No visible damage	No visible damage

APPENDIX A

RANDOM VIBRATION SPECTRA

(Extracted from MSC-01159, Rev. C)

MDA Spectrum

20 - 130 Hz @	0.30 g^2/Hz	} 1 min./axis
130 - 220 Hz @	-6dB/Oct.	
220 - 800 Hz @	0.10 g^2/Hz	
800 - 1400 Hz @	-12dB/Oct.	
1400 - 2000 Hz @	0.010 g^2/Hz	

Composite = 11.6 g.rms

(The above is the High Level Random criteria for the MDA Cylinder Skin - General Specification - Subzone 11-2).

OWS Spectrum

20 Hz @	0.010 g^2/Hz	} 1 min./axis
20 - 90 Hz @	+12dB/Oct.	
90 - 200 Hz @	3.70 g^2/Hz	
200 - 500 Hz @	-12dB/Oct.	
500 - 2000 Hz @	.095 g^2/Hz	

Composite = 29.1 g.rms

(The above is the Lift-off Random Vibration criteria for the OWS LH₂ Cylinder Tank Section, Stations 2970 to 3100, General Specification - Subzone 4-3.)

NOTE: The above criteria were selected, lacking any additional information, as representing the severest vibration in their respective areas. No information was available regarding Zone 1 on the OWS.

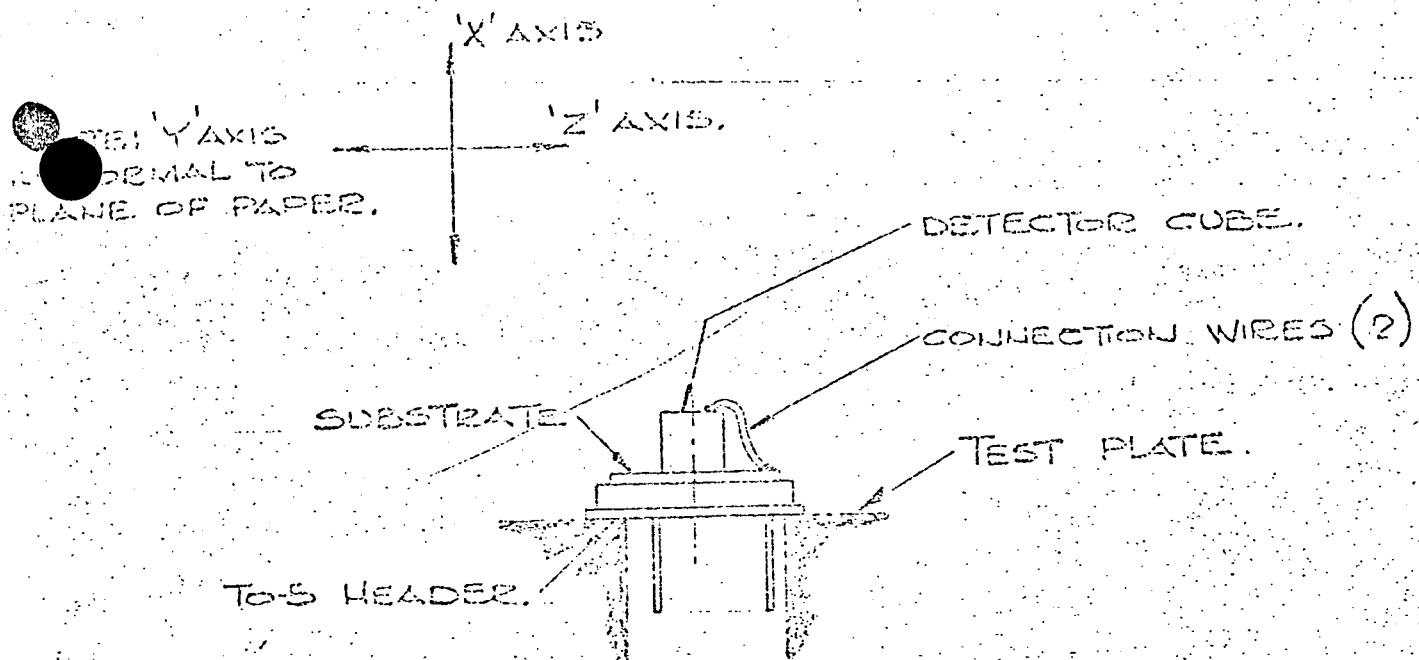


FIG. 1. DIAGRAM OF DETECTOR,
SHOWING VIBRATION AXES.

REPORT ON ACTION ITEMS
(Memo, B. C. Hall to D. L. Vincent, 12-1-70)

This report contains the response to actions items 1 and 2 contained in the above memo.

Item 1

A comparison of the various environmental requirements imposed on the EPS by reason of being mounted on the Skylab Multiple Docking Adapter (MDA) or the Orbital Workshop (OWS) zone 1 was made, together with those presumed to be imposed at the Preliminary Requirements Review (Nov. 6, 1970).

The results of this comparison are tabulated below:

Environment	Preliminary Requirements Review (1)	MDA	OWS (Zone 1)
Temperature (°F)	-60 to +195	-180 to +277	-200 to +300
Pressure-Launch & Ascent (mm.Hz) Orbit	--- ---	1086 to 10^{-8} (2) 10 ⁻⁸	760 to 10^{-8} (2) 10 ⁻⁸
Humidity (%RH)	---	0 to 45%	0 to 100%
Acceleration	---	4.7g flt. axis 2.0g lateral	4.7g flt. axis 2.0g lateral
Vibration	(3)	(3)	(3)
Shock	---	(4)	N/A
E.M.I	---	ED-2002-1032	SM-56669
Meteoroid Notes	---	IDENTICAL	
Radiation Light Atmospheric Comp. Air Movement	---	IDENTICAL	
Acoustic Noise	---	(5)	(5)
Contaminants	---	OVERBOARD DUMP MATERIAL	

Notes :

1. Environmental acceptance test ground rules (Enclosure 2).
2. In 7 mins. max. decompression rate = 6 psi/min.
3. See Appendix "A".
4. See Appendix "B".
5. See Appendix "C".

It can be seen that the temperature limits on the OWS are slightly wider than for the MDA, but it is not felt that these are enough to make a significant difference.

During the launch and ascent stage, the pressure environment is initially lower on the OWS than the MDA - 1 atmosphere as opposed to 1.4 atmospheres. The OWS will see the full range of relative humidity, whereas the MDA only reaches 45% R.H.

For vibration, there is a significant difference. The OWS will give appreciably higher levels of vibration than the MDA, approximately three times the magnitude, and this may well be more severe than we can design for within the maximum allocated weight. There appears to be no significant difference between the two locations regarding acoustic noise.

At this moment, we have no information available on either of the E.M.I. documents to determine if there is any significant difference in their requirements.

Acceleration, meteoroid notes, radiation, light, atmospheric composition, air movement and contaminants criteria are the same for both MDA and OWS.

To sum up, the present design of the EPS would conform to all the environmental requirements with the exception of vibration and possibly shock. Assuming the vibration in zone 1 to be at least as severe as zone 4-3, then it is considered that it would be extremely difficult to design to meet this level of vibration within the present maximum weight allocation.

Item 2

The EPS is being presently designed to the temperature, pressure, acceleration and vibration requirements for mounting on the MDA. The vibration levels used are those for zone 11-2, being the most severe conditions.

For shock we are designing to a 20g shock for total of 11 mseconds duration.

An attempt is being made to determine the maximum vibration level that the SSR detectors can stand, and a test report on the testing conducted to date is included. This testing is incomplete, but it is anticipated that it will recommence at 10 A.M. on 12-7-70. It is not anticipated that there will be any failure of the detectors, however, as their mass is extremely small. They would therefore require extremely high g levels to cause a bond failure or failure of the connection wires.

SSR have tested slightly larger detectors up to 100g. at 2000 Hz. They agree that the normal failure mode would be for the detector cube bond to the substrate to fail.

D. L. Vincent

Appendix "A"
Vibration Criteria

PRR

20 -	80 Hz @ +3dB/Oct.	Acceptance levels
30 -	350 Hz @ $0.04g^2/\text{Hz}$	1 min/axis min.
350 -	2000 Hz @ -3dB/Oct.	5 min/axis max.

(This random vibration spectrum is the only vibration criteria given in the PRR.)

MDA

Several spectra are given for different zones of the MDA. If we consider random vibration as probably being more severe than the sinusoidal inputs, the worst spectrum appears to be at zone 11-2, MDA Cylinder Skin, High Level Random Criteria.

20 -	$130 g^2/\text{Hz}$	
130 -	220 Hz @ -6dB/Oct.	
220 -	800 Hz @ $0.10 g^2/\text{Hz}$	1 min/axis
800 -	1400 Hz @ -12dB/Oct.	
1400 -	2000 Hz @ $0.010g^2/\text{Hz}$	
		Composite 116. g.r.m.s.

OWS

No vibration data for zone 1 on the OWS were available in MSC-01159 Rev. c, but comparison of the levels given for zone 4 shows that it can be expected that the levels could be as much as three times higher than for the most severe MDA environment.

Appendix "B" Shock Criteria

OWS

According to MSC-01159, Rev. C, shock requirements are not applicable to the OWS, with the exception of the normal MIL-STD-461 and 462 for transportation, storage and handling requirements.

MDA

As can be seen from the criteria below, the shock will vary depending upon the location of the EPS in relation to the docking post ring, reducing in severity as the distance from the ring increases.

<u>Distance from Nearest Docking Port Ring in Inches</u>	<u>Shock Spectrum</u>
0 - 12"	12.5 - 20 Hz @ 5.0 G's peak 20 - 1600 Hz @ +9 dB/oct 1600 - 5000 Hz @ 3000 G's peak 5000 - 10000 Hz @ -4 dB/oct 10000 Hz @ 1900 G's peak
13 - 49"	12.5 - 20 Hz @ 5.0 G's peak 20 - 1600 Hz @ 8 dB/oct 1600 - 5000 Hz @ 1500 G's peak 5000 - 10000 Hz @ 4 dB/oct 10000 Hz @ 950 G's peak
50 - 190"	12.5 - 20 Hz @ 5.0 G's peak 20 - 1600 Hz @ +6 dB/oct 1600 - 5000 Hz @ 380 G's peak 5000 - 10000 Hz @ -4 dB/oct 10000 Hz @ 240 G's peak
Greater than 190"	12.5 - 20 Hz @ 5.0 G's peak 20 - 1600 Hz @ +4 dB/oct 1600 - 5000 Hz @ 90 G's peak 5000 - 10000 Hz @ -4 dB/oct 10000 Hz @ 57 G's peak

Present Contractual Design Criteria

MIL-STD 810B Method III, 20G for 11 msec duration.

Appendix "C"
Acoustic Noise Criteria

MDA

<u>Geometric Mean Frequency (Hz)</u>	<u>Lift-Off</u>	<u>Boundary Layer</u>
5.0	110.0	110.0
6.3	111.5	112.0
8.0	113.0	113.5
10.0	115.0	115.0
12.5	117.0	116.5
16.0	118.5	118.5
20.0	121.0	120.0
25.0	123.0	123.0
31.5	124.5	125.5
40.0	127.0	127.0
50.0	128.5	128.5
63.0	131.0	130.0
80.0	133.0	131.0
100.0	133.0	131.5
125.0	133.0	132.0
160.0	132.0	132.0
200.0	131.0	131.5
250.0	130.5	131.0
315.0	129.5	129.0
400.0	128.5	128.0
500.0	127.5	127.0
630.0	126.5	126.0
800.0	125.0	124.0
1,000.0	124.0	123.0
1,250.0	123.0	122.0
1,600.0	121.5	121.0
2,000.0	120.0	120.0
2,500.0	119.0	119.0
3,150.0	117.0	116.5
4,000.0	116.0	113.0
5,000.0	113.0	109.5
6,300.0	110.0	106.0
8,000.0	109.0	103.0
10,000.0	107.0	100.0
Overall SPL	142.5	141.5
Duration	30.0	120.0

Appendix "C"
Continued

OVS

<u>Geometric Mean Frequency (Hz)</u>	<u>Lift-Off</u>	<u>Boundary Layer</u>
5.0	124.0	128.5
6.3	126.0	129.0
8.0	128.0	130.0
10.0	130.0	130.5
12.5	132.0	131.0
16.0	134.0	132.0
20.0	136.0	132.5
25.0	138.0	133.0
31.5	140.0	134.0
40.0	142.0	134.5
50.0	143.5	135.0
63.0	144.5	136.0
80.0	145.0	136.5
100.0	145.0	137.0
125.0	145.0	138.0
160.0	145.0	138.5
200.0	144.5	139.5
250.0	144.0	140.0
315.0	143.5	140.5
400.0	143.0	141.0
500.0	142.0	141.5
630.0	141.5	142.0
800.0	140.5	142.5
1,000.0	140.0	142.0
1,250.0	139.0	141.0
1,600.0	138.0	140.5
2,000.0	136.5	139.5
2,500.0	135.5	138.5
3,150.0	134.0	138.0
4,000.0	132.0	137.0
5,000.0	130.5	136.0
6,300.0	129.0	135.0
8,000.0	127.5	134.0
10,000.0	126.0	133.0
Overall SPL	156.0	153.5
Duration (Sec)	30.0	120.0

3.2.1.1.4 Electrical

The following are documents applicable to the assessment of the electrical requirements of the EPS.

<u>Subject Title</u>	<u>Page</u>
EPS Pulse Amplifier Specification (EPS-3)	111
Study of the EPS Preamplifier-Amplifier Time Response when Excited by a Rectangular Pulse of Varying Width and Constant Area (EPS-140)	115
EPS Post-Amplifier Time Constant and Gain Calculations (EPS-138)	122
EPS Heater Circuit	127
Analog Section Specifications	128
Unipolar and Bipolar Pulse Shaping Techniques: An Evaluation (EPS-65)	131
Pole-Zero Cancellation at the Output of the Charge Sensitive Preamplifier (EPS-70)	71
Selection of Time Constants for Accelerator Testing (EPS-199)	138
Summary of Power System Performance During the EPS Engineering Test Unit Thermal-Vacuum Testing (EPS-376)	139
Power Dissipation in Data Processor Modules (EPS-198)	144

<u>Subject Title</u>	<u>Page</u>
Parts List Changes for the Dual Differential Pulse Height Discriminator (EPS-197)	145
Part Value Changes for R2, R5(7), R5(9), R7(8), R7(9), R7(10), R8(7), R8(9), R10(8), R10(9), R10(10) and R13 of the Dual Differential Pulse Height Discriminator (EPS-90)	146
Experimental Verification of EPS Analog Design Before Manufacturing Release (EPS-85)	147
Selection of EPS Post-Amplifier Time Constants (EPS-89)	149
Selection of EPS Post-Amplifier Time Constants (EPS-86)	150
EPS Amplifier: An Analysis of the Filter Configuration and the Optimization of Signal Shapes (EPS-103)	156
EPS Housekeeping Specification (EPS-40)	174

EPS PULSE AMPLIFIER SPECIFICATIONS

1. Preamplifier

A. Charge Gain: $29.6 \pm 0.15 \frac{\text{mv}}{\text{mev}}$

B. Gain Stability

1. Temperature Stability: $0.02\%/^{\circ}\text{C}$

2. Stability as a function of supply voltage variation:
 $<0.5\%$ for ± 1.5 volt change in either or both power supplies.

C. Resolution (measured using a TC 202 at 0.53 μsec , bipolar):

Input Capacitance (pf)

	0	10	20	30	40	50
Resolution	$<10 \text{ Kev}$	$<10 \text{ Kev}$	$<10 \text{ Kev}$	$<10 \text{ Kev}$	$<10 \text{ Kev}$	$<10 \text{ Kev}$

D. Output Rise Time

Input Capacitance (pf)

	0	10	20	30	40	50
Rise Time	$<50\text{nsec}$	$<50\text{nsec}$	$<50\text{nsec}$	$<50\text{nsec}$	$<50\text{nsec}$	$<50\text{nsec}$

E. Output Decay Time Constant: $150.0 \pm 1.6\mu\text{sec}$

F. Integral Nonlinearity: $0.07\% \frac{(\Delta V_i)_{\text{max}}}{V_{\text{max}}} = \text{INL}$

G. Detector Bias Polarity and Range: 0 to +500 VDC

H. Test Input

1. Resistance: $49.9 \pm 0.5\Omega$

2. Capacitance: $1.0 \pm 0.1 \text{ pf}$

I. Permissible Load: 499Ω

J. Power Dissipation: $13.3 \text{ ma @ } +8 \text{ VDC} = 107 \text{ mw}$

$3.0 \text{ ma @ } -8 \text{ VDC} = 24 \text{ mw}$

131 mw

EPS PULSE AMPLIFIER SPECIFICATIONS

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II. Pulse Amplifier

- A. Pulse Gain: 41.6 ± 2
- B. Gain Stability
 - 1. Temperature Stability: $0.01\%/^{\circ}\text{C}$
 - 2. Stability as a function of supply voltage variation.
- C. Linear Range: 0 to +5.0 VDC
- D. Integral Nonlinearity: 0.07%
- E. Input Polarity: Positive
- F. Output Polarity: Positive
- G. Preamplifier-Amplifier Calibration: +5V = 10 mev
- H. Pulse Shaping Time Constant: 150 nsec - 500 nsec
- I. Pole-Zero Cancellation: Adjustable from 50 μsec to 100 μsec .
- J. Overload Recovery: Recovers from X10 overload in ≤ 2 NON overloaded pulse widths.
- K. Output Noise: ≤ 1.0 mv (FWHM) for no input (21.7 μvolts referred to input).
- L. Average Baseline Shift with Counting Range: $\leq -5\text{mV}$
- M. Baseline Stability
 - 1. Quiescent Value: 0.0 ± 5.0 mv
 - 2. Temperature Stability: 50 $\mu\text{V}/^{\circ}\text{C}$
- N. Output Coupling: Direct
- O. Permissible Load: 1 K Ω
- P. Power Consumption:
 - @ +8 VDC
 - @ -8 VDC

EPS PULSE AMPLIFIER SPECIFICATIONS

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III. Dual Pulse Height Discriminator

- A. Input Signal Pulse Height Range: 0 to +5 VDC
- B. Input Impedance: $\approx 4 \text{ K}\Omega$
- C. Input Coupling: Direct
- D. Pulse Pair Time Resolution: $\leq 100 \text{ nsec}$
- E. Stability of Discriminator Level
 - 1. Temperature Stability: $\leq 0.01\%/^{\circ}\text{C}$
 - 2. Stability as a function of supply voltage variation.
- F. Output Logic Signal Shape
 - 1. Width: Variable
 - 2. Height and Polarity: +2.4 V to 0.8 V
 - 3. Drive Capability: 10 TTL Loads
- G. Power Consumption:
 - @ +5 VDC
 - @ -5 VDC
 - @ -8 VDC

IV. Prescaler

- A. Scale Factor: 4
- B. Coupling: Direct
- C. Drive Requirements:
 - 1. Logic "1" Minimum: +2.4V @ +50 μamp
 - 2. Logic "0" Maximum: +0.6V @ -2.0 Mamp
- D. Minimum Toggle Frequency: 25 MHz

EPS PULSE AMPLIFIER SPECIFICATIONS

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E. Output

1. Logic "1" Minimum: +2.4V @ 1.0 Mamp
2. Logic "0" Maximum: +0.4V @ 2.0 Mamp
3. Rise Time Constant/Fall Time Constant: 160 nsec

F. Power Consumption: 52 Mamp @ +5 VDC

STUDY OF THE EPS PREAMPLIFIER-AMPLIFIER
TIME RESPONSE WHEN EXCITED BY A RECTANGULAR
PULSE OF VARYING WIDTH AND CONSTANT AREA

EPS-140

W. A. Oliveira

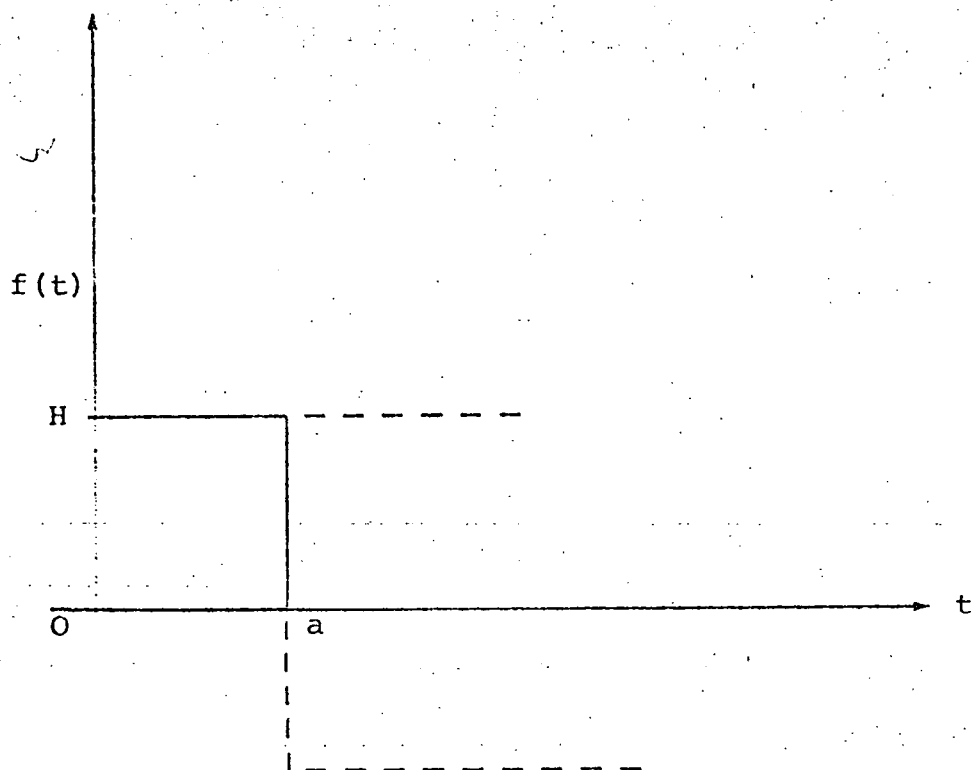


Figure 1

$f(t)$ can be represented as a combination of step functions:

$$f(t) = H[u(t) - u(t - a)]$$

(1)

The objective then is to obtain the output response of the preamplifier-amplifier system when $f(t)$ as given by (1) is applied to the preamplifier input.

It is hoped that this function would represent the output current of a semiconductor nuclear particle detector, allowing for the different charge collection times which are a function of the detector thickness and reverse bias voltage.

The output response can be obtained with the aid of the system's impulse response, which has already been derived and presented in a previous report, EPS-103. This function is given by:

$$h(t) = \frac{K}{2} e^{-t/T} \left(t^2 - \frac{1}{3T} t^3 \right) \quad (2)$$

With the knowledge of $f(t)$ and $h(t)$, at least two different approaches can be used to derive the system's output response to $f(t)$; 1) by using the convolution integral with $f(t)$ and $h(t)$ and 2) by using Laplace Transform techniques.

Just as an exercise and also as a check of the final result, let us derive the system's output response by using approach 1 and then approach 2.

Approach 1: Convolution Integral

In the field of linear systems analysis, there is a very useful theorem which states that the response of a system to a function $f(t)$ is equal to the convolution of $f(t)$ with the system's impulse response $h(t)$. Thus, let $y(t)$ be the desired response. The convolution integral is given by:

$$y(t) = \int_0^{\infty} f(t - \lambda) \times h(\lambda) d\lambda \quad (3)$$

where λ is the new integrating variable.

Recalling expression (1) and substituting the variable t by $t-\lambda$ yields:

$$f(t - \lambda) = HU(t - \lambda) - HU[t - \lambda - a] \quad (4)$$

Recalling expression (2) and substituting t by λ yields:

$$h(\lambda) = \frac{K}{2} e^{-\lambda/\tau} (\lambda^2 - \frac{1}{3\tau} \lambda^3) \quad (5)$$

Substituting (4) and (5) into (3) yields:

$$y(t) = \int_0^t [HU(t - \lambda) - HU(t - \lambda - a)] \times \frac{K}{2} e^{-\lambda/\tau} (\lambda^2 - \frac{1}{3\tau} \lambda^3) d\lambda \quad (6)$$

by multiplying the integrand and observing the limits of integration, one has:

$$y(t) = \frac{K \times H}{2} \int_0^t U(t - \lambda) e^{-\lambda/\tau} (\lambda^2 - \frac{1}{3\tau} \lambda^3) d\lambda \\ - \frac{K \times H}{2} \int_0^{t-a} U(t - \lambda - a) e^{-\lambda/\tau} (\lambda^2 - \frac{1}{3\tau} \lambda^3) d\lambda \quad (7)$$

$$y(t) = \frac{K \times H}{2} \left[\int_0^t U(t - \lambda) \lambda^2 e^{-\lambda/\tau} d\lambda - \frac{1}{3\tau} \int_0^t U(t - \lambda) \lambda^3 e^{-\lambda/\tau} d\lambda \right. \\ \left. - \int_0^{t-a} U(t - \lambda - a) \lambda^2 e^{-\lambda/\tau} d\lambda + \frac{1}{3\tau} \int_0^{t-a} U(t - \lambda - a) \lambda^3 e^{-\lambda/\tau} d\lambda \right] \quad (8)$$

The integrals can be evaluated by making use of the following formulation:

$$\int \chi^m e^{a\chi} d\chi = \frac{\chi^m e^{a\chi}}{a} - \frac{m}{a} \int \chi^{m-1} e^{a\chi} d\chi \quad (9)$$

from which one derives:

$$\int \chi e^{a\chi} d\chi = \frac{e^{a\chi}}{a^2} (a\chi - 1) \quad (10)$$

The first term in expression (8) becomes:

$$\begin{aligned} \int_0^t U(t-\lambda) \lambda^2 e^{-\lambda/\tau} d\lambda &= \frac{\lambda^2 e^{-\lambda/\tau}}{-\frac{1}{\tau}} \Big|_0^t - \frac{2}{(-\frac{1}{\tau})} \int_0^t \lambda e^{-\lambda/\tau} d\lambda \\ &= \left[-\tau \lambda^2 e^{-\frac{1}{\tau}\lambda} - 2\tau^3 e^{-\frac{1}{\tau}\lambda} \right]_0^t \end{aligned} \quad (11)$$

The second term of (8) yields:

$$\begin{aligned} -\frac{1}{3\tau} \int_0^t U(t-\lambda) \lambda^3 e^{-\frac{1}{\tau}\lambda} d\lambda &= -\frac{1}{3\tau} \left[\frac{\lambda^3 e^{-\frac{1}{\tau}\lambda}}{(-\frac{1}{\tau})} \Big|_0^t - \frac{3}{(-\frac{1}{\tau})} \int_0^t \lambda^2 e^{-\frac{1}{\tau}\lambda} d\lambda \right] \\ &= -\frac{1}{3\tau} \left[-\tau \lambda^3 e^{-\frac{1}{\tau}\lambda} + 3\tau (-\tau \lambda^2 e^{-\frac{1}{\tau}\lambda} - 2\tau^2 \lambda e^{-\frac{1}{\tau}\lambda} - 2\tau^3 e^{-\frac{1}{\tau}\lambda}) \right]_0^t \\ &= \frac{1}{3} \lambda^3 e^{-\frac{1}{\tau}\lambda} + \tau \lambda^2 e^{-\frac{1}{\tau}\lambda} + 2\tau^2 \lambda e^{-\frac{1}{\tau}\lambda} + 2\tau^3 e^{-\frac{1}{\tau}\lambda} \Big|_0^t \end{aligned} \quad (12)$$

By analogy with expressions (11) and (12) the third and fourth terms of expression (8) become:

$$-\int_0^{t-a} U(t - \lambda - a) 2e^{-\frac{1}{\tau}\lambda} d\lambda = \left[(\lambda^2 + 2\tau\lambda + 2\tau^2)\tau e^{-\frac{1}{\tau}\lambda} \right]_0^{(t-a)} \quad (13)$$

$$\begin{aligned} & + \frac{1}{3\tau} \int_0^{t-a} U(t - \lambda - a) \lambda^3 e^{-\frac{1}{\tau}\lambda} d\lambda \\ & = (-1) \left[\left(\frac{1}{3}\lambda^3 + \tau\lambda^2 + 2\tau^2\lambda + 2\tau^3 \right) e^{-\frac{1}{\tau}\lambda} \right]_0^{(t-a)} \end{aligned} \quad (14)$$

By grouping (11), (12), (13) and (14), one has:

$$\begin{aligned} y(t) = \frac{K_H}{2} & \left\{ \left[-(\lambda^2 + 2\tau\lambda + 2\tau^2)\tau + \frac{1}{3}\lambda^3 + \tau\lambda^2 + 2\tau^2\lambda + 2\tau^3 \right] e^{-\frac{1}{\tau}\lambda} \right|_0^t \\ & + \left[(\lambda^2 + 2\tau\lambda + 2\tau^2)\tau - \frac{1}{3}\lambda^3 - \tau\lambda^2 - 2\tau^2\lambda - 2\tau^3 \right] e^{-\frac{1}{\tau}\lambda} \right|_0^{t-a} \end{aligned}$$

or:

$$y(t) = \frac{K_H}{2} \left[\frac{1}{3}\lambda^3 e^{-\frac{1}{\tau}\lambda} \right|_0^t - \frac{1}{3}\lambda^3 e^{-\frac{1}{\tau}\lambda} \right|_0^{t-a} \right]$$

$$y(t) = \frac{K.H}{2} \left[\frac{1}{3} t^3 e^{-\frac{1}{\tau} t} - \frac{1}{3} (t-a)^3 e^{-\frac{1}{\tau} (t-a)} \right]$$

$$y(t) = \frac{K.H}{3 \times 2} \left[t^3 e^{-\frac{1}{\tau} t} - (t-a)^3 e^{-\frac{1}{\tau} t} \times e^{a/\tau} \right]$$

$$y(t) = \frac{K.H}{3 \times 2} e^{-\frac{1}{\tau} t} \left[t^3 - (t-a)^3 e^{a/\tau} \right] \quad (15)$$

Thus expression (15) represents the response of the EPS preamplifier-amplifier system to an input signal function as shown in Figure 1.

Since the input signal is supposed to maintain its area invariant as the width a is made to change, expression (15) can be modified to account for this condition:

$$y(t) = \frac{K \times A}{6a} e^{-\frac{1}{\tau} t} \left[t^3 - (t-a)^3 e^{a/\tau} \right] \quad (16)$$

where A is the area under the pulse.

Approach 2: Laplace Transform

Let us now try to arrive at expression (16) by using Laplace Transform methods. The Laplace transform of Expression (1) is given by:

$$F(s) = H \times \left[\frac{1}{s} - \frac{e^{-as}}{s} \right] \quad (17)$$

and for the system's impulse response one has:

$$H(s) = K \times \frac{s}{(s + \frac{1}{\tau})^4} \quad (18)$$

Thus the response of the system to $F(s)$ will be:

$$Y(s) = F(s) \times H(s) \quad (19)$$

and by substitution:

$$Y(s) = H \left(\frac{1 - e^{-as}}{s} \right) \times K \frac{s}{(s + \frac{1}{\tau})^4}$$

or

$$Y(s) = K \times H \left[\frac{1}{(s + \frac{1}{\tau})^4} - \frac{e^{-as}}{(s + \frac{1}{\tau})^4} \right] \quad (20)$$

Taking the inverse Laplace of both terms in (20), yields:

$$Y(t) = K \times H \left[\frac{1}{3!} \times t^3 e^{-\frac{1}{\tau}t} - \frac{1}{3!} (t - a)^3 e^{-\frac{1}{\tau}(t-a)} \right]$$

and by rearranging terms:

$$Y(t) = \frac{K \times H}{3!} \times e^{-\frac{1}{\tau}t} \left[t^3 - (t - a)^3 e^{a/\tau} \right]$$

and again making the substitution $H = \frac{A}{a}$ gives:

$$Y(t) = \frac{K \times A}{3! \times a} e^{-\frac{1}{\tau}t} \left[t^3 - (t - a)^3 e^{a/\tau} \right] \quad (21)$$

Comparison between expressions (16) and (21) shows that both approaches yielded the same result.

EPS POST AMPLIFIER TIME CONSTANT
AND GAIN CALCULATIONS
EPS-138

The impulse response of the preamplifier-amplifier system has been calculated and presented in a previous report, #EPS-103.

The expression representing the impulse response is given by:

$$h(t) = \frac{Q}{C_f} \times \frac{1}{R_3^2 \times C_1^2} \times \frac{1}{2} \times e^{-t/\tau} (t^2 - \frac{1}{3\tau} t^3) \quad (1)$$

where the parameter values are defined in Figure 1 below.

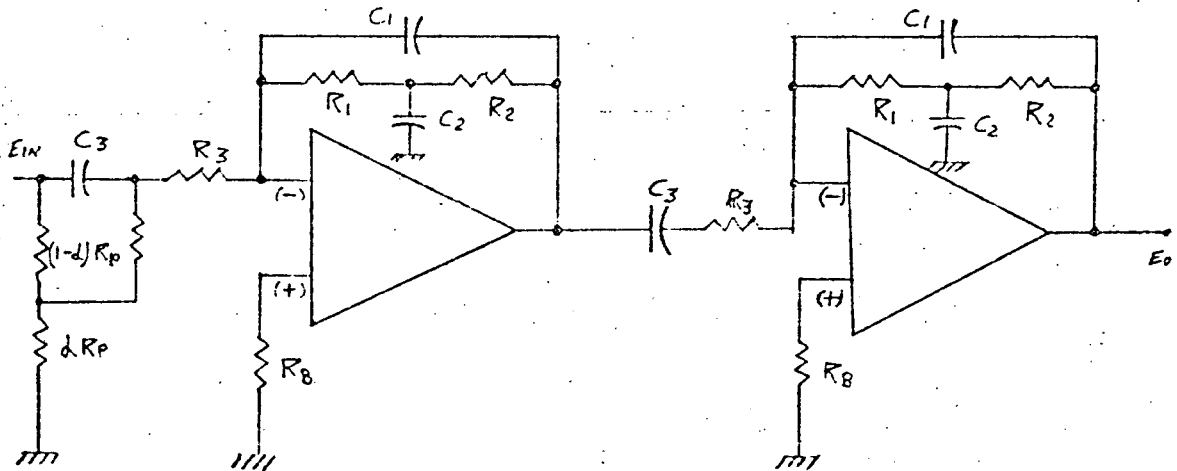


Figure 1

The common time-constant for both stages is given by:

$$\tau = \sqrt{R_1 R_2 C_1 C_2} \quad (2)$$

In order to have the impulse response of the system in the form of expression (1), certain relationships have to hold, as detailed in Report # EPS-103. One of these relations is that:

$$R_3 \times C_3 = \frac{R_1 \times R_2}{R_1 + R_2} \times C_2 \quad (3)$$

Another useful information from the same report is that the system's impulse response as given by expression (1) achieves its first maximum for a value of time given by:

$$t_{(\text{peak})} = 1.27 \times \tau \quad (4)$$

Thus this maximum of $h(t)$ can be obtained by substituting (4) into (1):

$$h(t)_{\text{max}} = \frac{Q}{C_F} \times \frac{1}{R_3^2 C_1^2} \times \frac{1}{2} \times 1^{-1.27\tau/t} \\ \left[(1.27\tau)^2 - \frac{1}{3\tau} (1.27\tau)^3 \right]$$

or:

$$h(t)_{\text{max}} = \frac{Q}{C_f} \times \frac{1}{R_3^2 C_1^2} \times \frac{1}{2} \times 1^{-1.27} \times (1.27)^2 \tau^2 \left[1 - \frac{1.27}{3} \right]$$

or:

$$h(t)_{\text{max}} = \frac{Q}{C_f} \times \frac{1}{R_3^2 C_1^2} \times .1306 \tau^2 \quad (5)$$

In Expression (5) $\frac{Q}{C_f}$ is the peak amplitude of the signal coming from the preamplifier. Thus, by rearranging expression (5), the peak gain of the post amplifier becomes:

$$\frac{h(t)_{\text{max}}}{Q/C_f} = \frac{.1306}{R_3^2 C_1^2} \times \tau^2$$

or:

$$A_{Vpeak} = \frac{.1306}{R_3^2 C_1^2} \times \tau^2 \quad (6)$$

Another relationship which will be used here is also previously derived in Report #EPS-103, and is given by:

$$R_2 = \frac{R_1 \times \tau}{2R_1 C_2 - \tau} \quad (7)$$

In order to arrive at numerical values for the six time constant determining parameters, R_1 , R_2 , R_3 , C_1 , C_2 and C_3 , one has available equations (2), (3), (6) and (7). This situation enables one to conveniently choose any two values among the original six and then solve the available expressions for the remaining four parameters.

At this point it is in order to present some clarifications about the conditions that lead to the pulse gain-time constant calculation results.

Firstly, the form of expression (1) is only valid if certain constraints are imposed on the networks of both active filter stages. These constraints are:

1. The poles of the input and feedback networks transadmittances must coincide, and thus cancel each other. This condition gives rise to expression (3).
2. The zeros of the feedback networks transadmittances for both filters must be real and coincide with each other (multiple poles in the transfer function).

3. The input network of the first filter stage must have a zero in its transfer function that coincides with the pole of the signal function at the input (preamplifier output).

Secondly, these same conditions guarantee that the damping factor of the output response be equal to one, and as a consequence no crossing of the baseline at the output of the first stage should occur, and only one crossing at the output of the second stage. In both cases, one achieves the fastest return to the baseline.

Let us now elaborate a little more on equations (2), (3), (6) and (7) in order to explicitly show the solutions for the parameters we are interested in finding numerical values.

From (6), solving for R_3 one has:

$$R_3 = \sqrt{\frac{.1306}{A_V}} \times \frac{\tau}{C_1} \quad (8)$$

From (2), solving for R_1 yields:

$$R_1 = \frac{\tau^2}{R_2 C_1 C_2} \quad (9)$$

And by substituting the value of R_1 as given by (9) into equation (7) results:

$$R_2^2 - \frac{2\tau}{C_1} R_2 = \frac{\tau^2}{C_1 C_2} = 0 \quad (10)$$

The solutions to equation (10) are:

$$R_2 = \frac{\tau}{C_1} \pm \sqrt{\frac{\tau^2}{C_1^2} - \frac{\tau^2}{C_1 C_2}}$$

$$R_2 = \frac{\tau}{C_1} \left(1 \pm \sqrt{1 - \frac{C_1}{C_2}} \right) \quad (11)$$

Expression (11) tells us a few things: for C_2 greater than C_1 there will be two distinct values of R_2 (and consequently R_1) that will satisfy all the requirements. For C_2 equal to C_1 , R_2 will be single valued:

$$R_2 = R_1 = \tau/C_1 \quad (12)$$

For C_2 smaller than C_1 , then no real value for R_2 (and R_1) will exist that will satisfy the requirements. This means that R_2 (and R_1) would have to be impedances with both real and imaginary parts. Of course, this third condition is of no practical value for the sake of network simplicity.

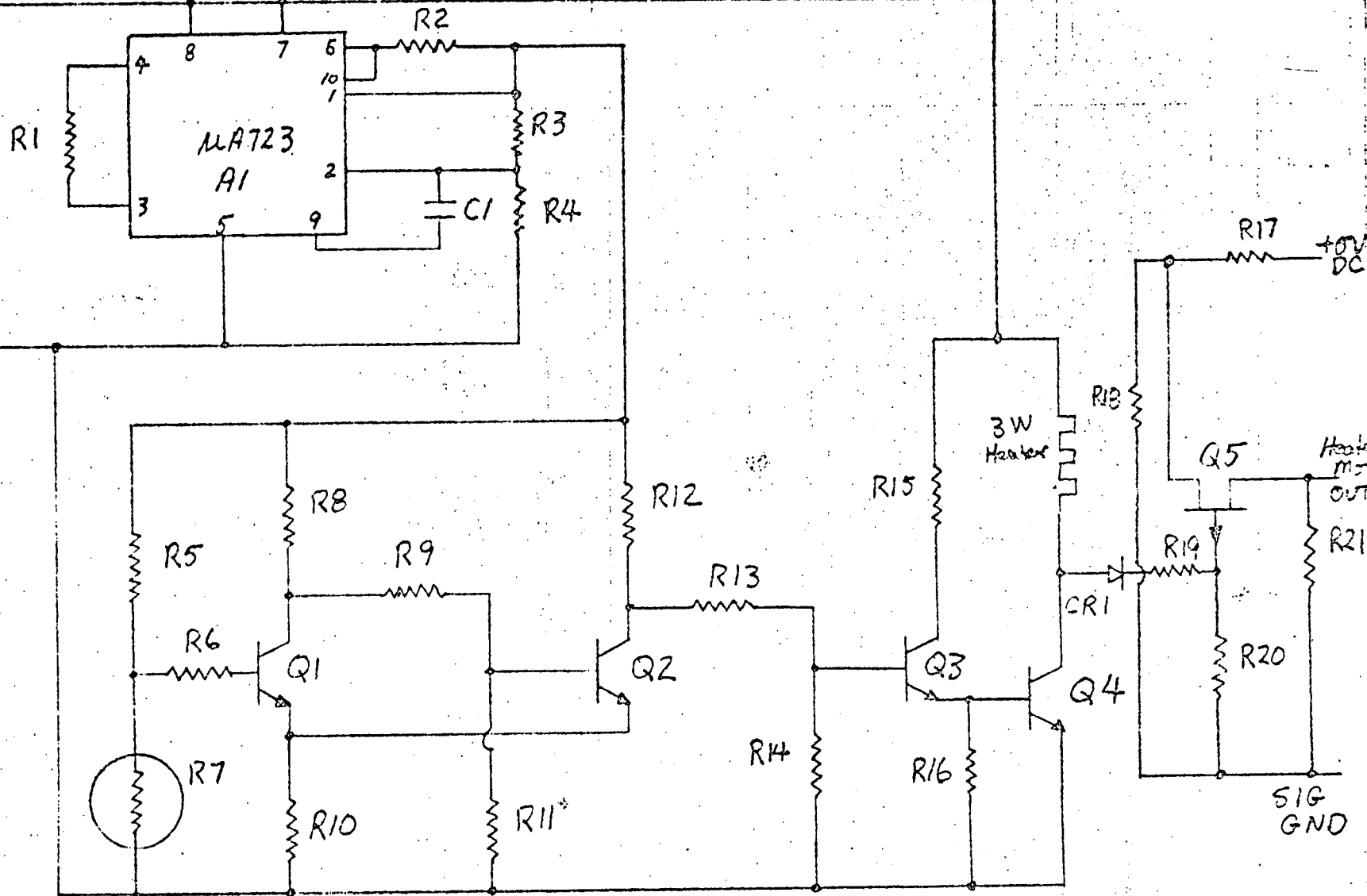
Expression (3) can now be solved for C_3 :

$$C_3 = \frac{R_1 \times R_2}{R_1 + R_2} \times C_2 \times \frac{1}{R_3} \quad (13)$$

28V
IN

POWER
GND

127



EPS
Heater Circuit

BEC 2/17/71

ANALOG SECTION SPECIFICATIONS

I. Preamplifier

A. Charge Gain: $12.0 \pm 0.25 \frac{\text{Mv}}{\text{MeV}}$

1. Temperature Stability: $0.02\%/^{\circ}\text{C}$

2. Stability as a function of supply voltage variation

C. Resolution (Measured using a TC202 at $0.5 \mu\text{sec}$):

Input Capacitance (pf)

	0	10	20	30	40	50
Resolution	$\leq 10\text{keV}$	$\leq 10\text{keV}$	$\leq 10\text{keV}$	$\leq 10\text{keV}$	$\leq 10\text{keV}$	$\leq 10\text{keV}$

D. Output Rise Time:

Input Capacitance

	0	10	20	30	40	50
Rise Time	$\leq 50\text{Nsec}$	$\leq 50\text{Nsec}$	$\leq 50\text{Nsec}$	$\leq 50\text{Nsec}$	$\leq 50\text{Nsec}$	$\leq 50\text{Nsec}$

E. Output Delay Time Constant: $80.0 \pm 1.6 \mu\text{Sec}$

F. Integral Nonlinearity = $\leq 0.07\%$ $\frac{(\Delta V_i)_{\text{max}}}{V_{\text{max}}} = \text{INL}$

G. Detector Bias Polarity and Range: 0 to +500 Vdc

H. Test Input

1. Resistance: $49.9 \pm 0.5\Omega$

2. Capacitance: $2.2 \pm .05\text{pf}$

I. Permissible Load: 499Ω

J. Power Dissipation: @ +8Vdc

@ -8Vdc

II. Pulse Amplifier

A. Pulse Gain: 41.6 ± 2

B. Gain Stability

1. Temperature Stability: $0.01\%/^{\circ}\text{C}$
2. Stability as a function of Supply Voltage Var.

C. Linear Range: 0 to +5.0 Vdc

D. Integral Nonlinearity: $\leq 0.07\%$.

E. Input Polarity: Positive

F. Output Polarity: Positive

G. Preamplifier - Amplifier Calibration: +5V = 10 MeV

H. Pulse Shaping: 150nsec - 500 nsec

I. Pole-Zero Cancellation: Adjustable from 50 μsec to
100 μsec

J. Overload Recovery: Recovers from X2 overload in ≤ 2
non overloaded pulse widths

K. Output Noise: ≤ 1.0 mV for no input

L. Average Baseline Shift with Counting Rate

M. Baseline Stability

1. Quiescent Value: 0.0 ± 5.0 mV
2. Temperature Stability: $50 \mu\text{V}/^{\circ}\text{C}$

N. Output Coupling: Direct

O. Permissible Load: $1\text{K}\Omega$

P. Power Consumption: @ +8Vdc
@ -8Vdc

III. Dual Pulse Height Discriminator

- A. Input Signal Pulse Height Range: 0 to +5 Vdc
- B. Input Impedance: $\approx 4K\Omega$
- C. Input Coupling: Direct
- D. Pulse Pair Time Resolution: ≤ 100 nsec
- E. Stability of Discriminator Level
 - 1. Temperature Stability: $\leq 0.01\%/^{\circ}C$
 - 2. Stability as a function of Supply Voltage Variations
- F. Output Logic Signal Shape
 - 1. Width: Variable
 - 2. Height and Polarity: +2.4V to 0.8V
 - 3. Drive Capability: 10 TTL Loads
- G. Power Consumption
 - @ +5Vdc
 - @ -5Vdc
 - @ -8Vdc

IV. Prescaler

- A. Scale Factor: 4
- B. Coupling: Direct
- C. Drive Requirements
 - 1. Logic "1": +2.4Vdc
 - 2. Logic "0":

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./ 673-10 SLDG./Beta PLANT/HASD DATE 12-15-70
ORGN. ZONE FAC. Ref: EPS-65

FROM R. W. O'Neill

DEPT./ 673-10 SLDG./Beta PLANT/HASD EXT. 481
ORGN. ZONE FAC.

SUBJECT: Unipolar and Bipolar Pulse Shaping Techniques: An Evaluation

An evaluation of bipolar and unipolar pulse shaping techniques, with emphasis on application in the EPS, was made. The advantages and disadvantages for a two-integrator single-differentiator system are outlined as follows.

Bipolar

1. No baseline restorer required due to symmetry of the pulses about the baseline.
2. Poorer pulse-to-noise ratio (than unipolar) in a system with otherwise identical components and inputs.
3. Longer shaping time (than unipolar), which decreases the maximum count rate in otherwise equivalent systems.

Unipolar

1. Requires a baseline restorer, which increases the component count and power by 50%.
2. Less amplifier gain and bandwidth required for a given time-constant than required for bipolar.
3. Better pulse-to-noise ratio than bipolar in otherwise identical systems.

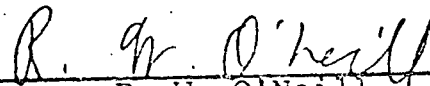
Breadboarding and testing has indicated that the disadvantages of the bipolar system could be overcome by proper design. The component count would be reduced, giving a bipolar system a decided advantage, which has dictated its choice over the unipolar system. The decision to use bipolar shaping in the EPS was made December 10, 1970.

Temperature Gain Stability Calculations

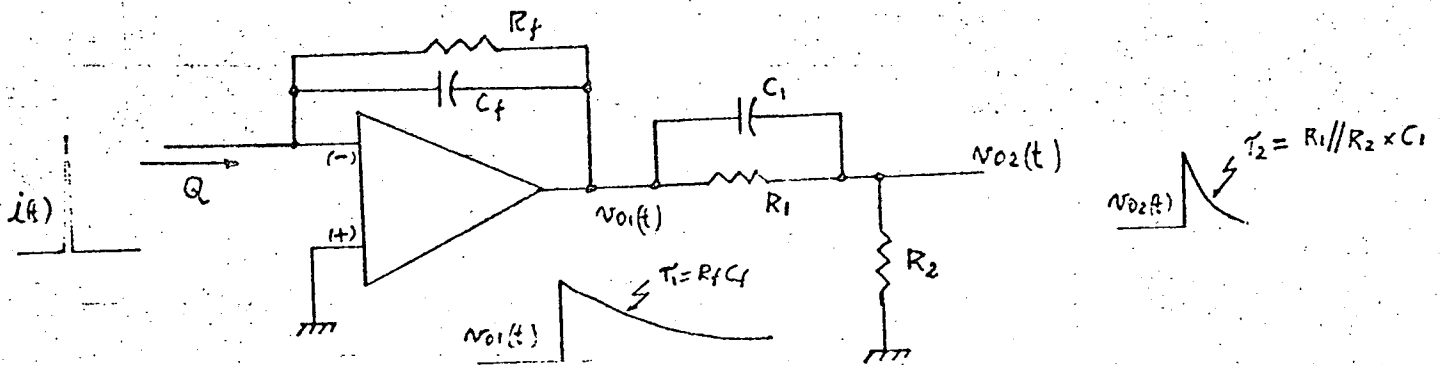
An IBM electronic circuit analysis program was run to evaluate the effect of expected temperature sensitivities of the components on the gain stability of the pulse amplifiers. A value

of $\pm 0.8\%$ was chosen to simulate the component variations with temperature over the range from -25°C to $+25^{\circ}\text{C}$. This corresponds to 50 parts per million per $^{\circ}\text{C}$ for the resistors and 100 parts per million per $^{\circ}\text{C}$ for the capacitors, giving a 0.75% variation, which was rounded to 0.8% to simplify computations. The peak voltage variation was 0.2% for unipolar and 0.07% for bipolar.

The values took advantage of the inherent tracking of similar resistors and capacitors, but the combinations were such that maximum resistance was coupled with maximum capacitance and minimum resistance was combined with minimum capacitance. Resistance ratios, as well as capacitance ratios, were constant, giving maximum time-constant changes over the temperature range.


R. W. O'Neill

POLE-ZERO CANCELLATION AT THE OUTPUT OF THE CHARGE SENSITIVE PREAMPLIFIER



Due to input sensitivity considerations as well as to achieve high resolution, the feedback network elements R_f and C_f are chosen such that the product $R_f \times C_f$ is much greater than the duration of the pulse carrying the energy-amplitude relationship at the output of the shaping amplifier. Thus, it becomes necessary to interface a network between the preamplifier and postamplifier in order to shorten the pulse before amplification.

In order to achieve optimum overload recovery performance and for better high count-rate response it is mandatory that the waveform at the output of the pulse shortening network be monotonic decreasing in nature, that is, no crossing of the baseline is allowed.

This requirement can be achieved by the use of the RC network at the output of the CSA as shown in the figure above.

Suppose the CSA is excited by an impulse of current of charge Q . The time domain output voltage is given by:

$$v_{01}(t) = -\frac{Q}{C_f} e^{-\frac{1}{R_f C_f} t} \quad (1)$$

which in the frequency domain assumes the form:

$$V_{01}(s) = \frac{Q}{C_f} \times \frac{1}{s + \frac{1}{R_f C_f}} \quad (2)$$

Now, taking the transfer function of the $R_1 R_2 C_1$ network one finds:

$$\frac{V_{02}(s)}{V_{01}(s)} = \frac{s + \frac{1}{R_1 C_1}}{s + \frac{1}{(R_1 // R_2) C_1}} \quad (3)$$

Multiplying (2) and (3) gives

$$V_{02}(s) = \frac{s + \frac{1}{R_1 C_1}}{s + \frac{1}{(R_1 // R_2) C_1}} \times \frac{1}{s + \frac{1}{R_f C_f}} \times \frac{Q}{C_f} \quad (4)$$

If the zero of $V_{02}(s)$, $\frac{1}{R_1 C_1}$, is made numerically equal to the pole of $V_{02}(s)$, $\frac{1}{R_f C_f}$, then there is what is usually called a pole-zero cancellation, and expression (4) becomes:

$$V_{02}(s) = \frac{Q}{C_f} \times \frac{1}{s + \frac{1}{(R_1 // R_2) C_1}} \quad (5)$$

which has the time domain expression given by

$$V_{02}(t) = \frac{Q}{C_f} \times e^{-\frac{1}{(R_1 // R_2) C_1} t} \quad (6)$$

Equation (6) shows that the voltage $V_{02}(t)$ is a simple exponential of time constant $(R_1//R_2)C_1$. Since $(R_1//R_2)C_1$ can be made much smaller than $R_f C_f$, the objective of shortening the pulse decay has been achieved, without baseline crossing.

In order to have no baseline crossing, one must have perfect pole-zero cancellation at all times. This means that $R_1 C_1 = R_f C_f$ must be true under all conditions.

PULSE PILE-UP AT THE OUTPUT OF THE POLE-ZERO CANCELLATION NETWORK

In order to find the instantaneous baseline fluctuations due to pulse overlapping in high count-rate applications, Campbell's theorem can be applied:

$$v_0(\text{rms}) = \sqrt{n \int_0^\infty |v_0(t)|^2 dt} \quad (7)$$

where $v_0(t)$ is given by equation (6).

Substituting $v_0(t)$ into (7) and evaluating the integral one finds:

$$v_0(\text{rms}) = \frac{Q}{C_f} \left[\frac{n}{2} (R_1//R_2) C_1 \right]^{1/2} \quad (8)$$

POST-AMPLIFIER OUTPUT PILE-UP EFFECT

At the output of the two stage integrators with a unipolar pulse having a certain amount of undershoot due to an imperfect pole-zero cancellation of the preamplifier, the rms dispersion of the pulse amplitude can be found by applying once more Campbell's theorem.

$$v_0(\text{rms}) = \sqrt{n \int_0^\infty |f(t)|^2 dt} \quad (7)$$

where, in this case:

$$f(t) = \frac{T_j}{T_s} e^{-\frac{1}{T_s} t} \quad (9)$$

and, T_j = resolving time of the unipolar pulse main lobe
 T_s = Time constant of the undershoot.

Substituting equation (9) into (7) one has:

$$[v_0(rms)]_{REL} = 0.707 \sqrt{\frac{T_j}{T_s} n T_j} \quad (10)$$

In equation (10) the following definitions apply:

$$[v_0(rms)]_{ABS} = [v_0(rms)]_{REL} \times V_{peak}(\text{normal pulse}) \times 100\%$$

$\frac{T_j}{T_s}$ is the fractional undershoot.

nT_j is the duty cycle at the shaping amp output.

As an example of what can be expected for the instantaneous base-line fluctuations, consider the following practical parameters:

$$T_j = 1 \mu\text{sec}, T_s = 50 \mu\text{sec}, n = 2.5 \times 10^5 \text{ cps.}$$

Substituting these values into equation (10) yields:

$$[v_0(\text{rms})]_{\text{REL}} = .707 \frac{1}{50} \times 2.5 \times 10^{+5} \approx 10^{-5}$$

$$[v_0(\text{rms})]_{\text{REL}} \approx 5\%$$

Note that $\frac{T_j}{T_s} = \frac{1}{50} = 2\%$ undershoot. This figure can be made smaller by carefully adjusting the P-Z cancellation network.

INTERDEPARTMENTAL COMMUNICATION

TO Distribution

DEPT./ 673-10 BLDG./Beta PLANT/HASD DATE 4-15-71
ORG. ZONE FAC. Ref: EPS-199

FROM R. S. Lindsey

DEPT./ 673-10 BLDG./Beta PLANT/HASD EXT. 422
ORG. ZONE FAC.

SUBJECT: Selection of Time Constants for Accelerator Testing

Six EPS post amplifiers are needed for analog electronics/detector testing presently scheduled for the NASA/MSX Van de Graaff in May. These six amplifiers will be housed in two NIM modules as follows:

1 MM Module - 150 nsec

220 nsec

290 nsec

2 MM Module - 360 nsec

430 nsec

500 nsec

R. S. Lindsey

R. S. Lindsey

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SUMMARY OF POWER SYSTEM PERFORMANCE
DURING THE
EPS ENG. TEST UNIT
THERMAL-VACUUM TESTING

A. INPUT FILTER

Due to the test setup (i.e., the EPS mounted inside a vacuum chamber) and a lack of the necessary test equipment, it was not possible to perform any RFI/EMI testing on the EPS during Thermal-Vacuum testing. Therefore, it is not known whether the Input Filter met its design specifications at the temperatures encountered during this test. However, since the electronic components utilized in this subsystem do not vary significantly with temperature and are insensitive to vacuum, and since this unit had already passed an EMI test at room temperature, it is assumed that the Input Filter would have allowed the EPS to pass an EMI test at any temperature within the operating limits specified for the instrument.

Since both power supplies and the Heater Control circuit were always within specification (see below), the Input Filter could not have modified the primary power (+28 Vdc) to these circuits. Therefore, the conclusion reached is that the Input Filter performed as expected.

B. DETECTOR BIAS SUPPLY

The Detector Bias Supply met all of the performance specifications during the Thermal-Vacuum testing. A summary of its performance compared to the required specifications is given below.

Specification
(Ref. EPS-41)

Input Voltage: $27.5 \pm 2.5\text{Vdc}$
Input Current: $I_{in} \leq 30 \text{ ma}$ @
28Vdc

Oper. Temp Range: -25°C to
 $+25^{\circ}\text{C}$

Surv. Temp Range: -50°C to
 $+50^{\circ}\text{C}$

Output Voltage: $350 \pm 17.5\text{Vdc}$

Performance
Thermal-Vacuum Test

Operated from $28 \pm 4\text{Vdc}$
 $I_{in} \leq 25 \text{ ma}$

Operated from -45°C to
 $+43^{\circ}\text{C}$

$346.9 \pm 0.9\text{Vdc}$ over Temp
range of -45°C to $+43^{\circ}\text{C}$

C. LOW VOLTAGE POWER SUPPLY

The LVPS met most of the required specifications during the Eng. Test Unit Thermal-Vacuum testing. The summary below gives actual performance and the required performance.

Specification
(Ref. EPS-45)

Input Voltage: $27.5 \pm 2.5\text{Vdc}$
Input Current: $I_{in} \leq 557 \text{ ma}$

Oper. Temp Range: -25°C to
 $+25^{\circ}\text{C}$

Surv. Temp Range: -50°C to
 $+50^{\circ}\text{C}$

Performance
Thermal-Vacuum Test

Operated from 24 to 31Vdc
 $I_{in} \leq 550 \text{ ma}$

Operated from -45°C to
 $+43^{\circ}\text{C}$

Outputs:

+0.2		
+8 -0.0 Vdc	8.05 to 8.08	-27°C ≤ T ≤ 23°C
+0.2		
-8 -0.0 Vdc	-8.08 to -8.13	"
+5 ± 0.3 Vdc	5.00 to 5.03	"
-5 ± 0.3 Vdc	*-5.258 to -5.317	"
+25 ± 2.0 Vdc	25.56 to 25.64	"
-15 ± 2.0 Vdc	-16.63 to -16.73	"
3.0 ± .01 Vdc	3.003 to 3.009	"

*Note that the -5 Vdc output was out of specification. This output was out of spec. at room temperature ($V_{out} = -5.317$, spec. allows -5.300). This is a result of generating both the +5 output and the -5 output from one secondary winding on the LVPS transformer. Since the load current for the +5 is approximately 900 ma and the load current for the -5 V output is only approximately 120 ma there will be a considerable difference in the two output voltages. It was decided to set the output voltages of this winding with the +5 V output (i.e., adjust the number of turns on this winding to get a minimum of +5.00 Vdc out and take whatever comes out for the -5 V). Since the -5 V output is out of specification by only 0.3% worst case, this should be acceptable.

D. HEATER CONTROL

During the Thermal-Vacuum testing, the internal skin heaters turned on during Test Case #2 (operating during a cold orbit) when the internal package temperature had reached -0.5°C. When the additional six watts were dissipated within the EPS, the package temperature started

increasing. The temperature was monitored for an additional two hours and increased to $+2.9^{\circ}\text{C}$ during this time. It is surmised that the package temperature would have eventually reached $+10^{\circ}\text{C}$ and the heater would have turned off.

During Test Case #1 (operating during a hot orbit) the package temperature started out at -35°C . With all electronics power on and the heaters on, the package temperature increased to $+9.5^{\circ}\text{C}$ in seven hours. At this point, the heaters turned off and the package temperature immediately stabilized at $+10^{\circ}\text{C}$ where it remained for the remaining eight hours of the test.

Since during the course of the Thermal-Vacuum testing, the EPS package temperature ranged between -45°C and $+43^{\circ}\text{C}$, it is obvious that the Heater Control Subassembly will operate over and survive this temperature range.

A. NOT CORRECTED FOR ADC

Temp °C	+5 Volt	+8 Volt	-8 Volt	+25 Volt	+350 Volt	-15 Volt	-5 Volt	+3 Volt
+43	5.044	8.114	-8.165	25.70	346.6	-16.62	-5.329	3.003
+23	5.034	8.084	-8.131	25.64	346.1	-16.63	-5.317	3.009
+11	5.024	8.064	-8.102	25.59	345.6	-16.62	-5.297	2.999
0	5.014	8.054	-8.096	25.54	345.6	-16.63	-5.281	2.996
-27	4.976	8.006	-8.038	25.43	345.6	-16.64	-5.232	2.993
-45	4.916	7.928	-7.958	25.27	346.1	-16.53	-5.142	2.987

B. CORRECTED FOR ADC

Temp °C	+5 Volt	+8 Volt	-8 Volt	+25 Volt	350 Volt	-15 Volt	-5 Volt	+3 Volt
+43	5.044	8.114	-8.165	25.65	346.2	-16.62	-5.329	2.999
+23	5.034	8.084	-8.131	25.64	346.1	-16.63	-5.317	3.009
+11	5.032	8.084	-8.131	25.63	346.3	-16.67	-5.317	3.003
0	5.028	8.078	-8.117	25.62	346.8	-16.66	-5.307	3.005
-27	5.000	8.046	-8.078	25.56	347.3	-16.73	-5.258	3.007
-45	4.940	7.968	-7.998	25.40	347.8	-16.62	-5.168	3.001

TABLE I. EPS ENG TEST UNIT PERFORMANCE DURING THERMAL-VACUUM TEST.

INTERDEPARTMENTAL COMMUNICATION

D. L. Vincent

DEPT./ 673-10 BLDG./ Beta PLANT/ HASD DATE 4-14-71
COGN. EXT. Ref: EPS-198

FROM

C. L. Fletcher

DEPT./ 673-10 BLDG./ Beta PLANT/ HASD EXT. 481
COGN.

SUBJECT: Power Dissipation in Data Processor Modules

The power dissipation for the various data processor modules was measured individually in the operating mode on the bread-board unit. Individual module power is listed below.

Counter/Memory	5 volts @ 47 ma	--- 234 mW
Sequence Control/Line Rec.	5 volts @ 19.1 ma	--- 96 mW
Counter Control/Clock	-5 volts @ 2 ma	--- 10 mW
Digital Data Comp.	5 volts @ 36.7 ma	--- 184 mW
ADC Logic/MUX Cont.	5 volts @ 24 ma	--- 120 mW
Buffer/Word Sync Gen	5 volts @ 52 ma	--- 260 mW
Total	5 volts @ 180 ma	900 mW
	-5 volts @ 2 ma	10 mW

It should be noted that ten counter/memory modules will be required for a complete unit. Thus, the total power required for a complete unit will be approximately 603 ma from the positive 5 volt supply and 2 ma from the negative 5 volt supply. If the positive supply voltage is increased to 5.1 volts, the current increases approximately 3 percent.

C. L. Fletcher

cc: B. E. Curtsinger
B. C. Hall
R. S. Lindsey

INTERDEPARTMENTAL COMMUNICATION

G. R. Smith

DEPT./
ORGN. 673-10 BLDG./
ZONE Beta PLANT/
FAC. HASD DATE 4-12-71
Ref: EPS-197

FROM

R. S. Lindsey

DEPT./
ORGN. 673-10 BLDG./
ZONE Beta PLANT/
FAC. HASD EXT. 422

SUBJECT:

Parts List Change for the Dual Differential Pulse Height
Discriminator

Recently completed testing conducted on the Dual Differential
Pulse Height Discriminator indicates the need for several
parts value changes. The new values are:

	R5	R6	R7
Channel 1	RNC50H7500FR	3260H-1-201	RNC50H4640FR

R. S. Lindsey

R. S. Lindsey

cc: B. E. Curtsinger

INTERDEPARTMENTAL COMMUNICATION

TO R. B. Hendrix

DEPT./ 673-10 BLDG./ Beta PLANT/ HASD DATE 12-29-70
ORGN. ZONE FAC. Ref: EPS-90

FROM R. S. Lindsey

DEPT./ 673-10 BLDG./ Beta PLANT/ HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT: Part Value Changes for R2, R5(7), R5(9), R7(8), R7(9), R7(10), R8(7), R8(9), R10(8), R10(9), R10(10) and R13 of the Dual Differential Pulse Height Discriminator

The subject MEPCO RNC50 resistors are officially changed to the following values:

<u>Resistor</u>	<u>New Value</u>
R2	6040 Ω
R5(7)	576 Ω
R5(9)	249 Ω
R7(8)	1180 Ω
R7(9)	1330 Ω
R7(10)	1500 Ω
R8(7)	576 Ω
R8(9)	249 Ω
R10(8)	1180 Ω
R10(9)	1330 Ω
R10(10)	1500 Ω
R13	6040 Ω

These values for R2 and R13 hold only if the input impedance of the Resolution Monitor is $4990 \Omega \pm 1\%$. If any change is made in this circuit's input impedance, please inform me so that compensating changes can be made in R2 and R3.

In addition, potentiometers R6 and R9 could possibly change to 3260 H (side screw) types.

R. S. Lindsey
R. S. Lindsey

cc: W. Oliveira

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall DEPT./ 673-10 BLDG./ Beta PLANT/ HASD DATE 12-28-70
ORGN. Ref: EPS-85

FROM R. S. Lindsey DEPT./ 673-10 BLDG./ Beta PLANT/ HASD EXT. 422
ORGN.

SUBJECT: Experimental Varification of EPS Analog Design Before Manufacturing Release

Prior to freezing the EPS analog design, a detailed attempt should be made to verify its adequacy and ferret out any shortcomings. This testing should be directed at the system performance level and should involve the detectors, preamplifier, amplifiers, pulse height discriminators, their interwiring and the overall packaging scheme. A large fraction of the testing can be accomplished at the bench. An incomplete listing of these tests is:

1. System gain accuracy
2. System gain stability
 - a. Temperature
 - b. Power supply variations
 - c. Charge collection time.
3. System resolution
4. System resolution stability
 - a. Temperature
 - b. Counting rate and spectrum
5. System baseline
6. System baseline stability
 - a. Temperature
 - b. Power Supply Variations
7. System Overload Recovery
8. System overload recovery temperature stability
9. System integral nonlinearity
10. System power requirements

Most of the required equipment necessary to accomplish the preceding list of tests is on hand or could be borrowed. One outstanding item, however, is markedly absent. This item is a fast, linear, noise free pulse stretcher capable of operation

at $> 250,000/\text{sec}$ rates. This item will have to be developed or the (LMM)³ detector channel cannot be tested. Since EPS bases its rate performance capabilities on this channel's qualities, I feel that the need to perform adequate, well documented tests is paramount. If work is not started on this unit this week, the probability of its completion by January 15 will approach zero.

The second type of testing necessary to demonstrate the adequacy of the EPS design involves use of flight type detectors and charged particles. Due to the thickness of dead layers on SSR cubical detectors, alpha sources are of little use. In addition, the (LMM)³ detectors permit sufficient electron scattering to render the data largely useless. The only remaining form of handy charged particle is the proton. Results obtained in earlier IFS testing gave the indication that this type of particle is acceptable for resolution and gain measurements.

It is my belief that someone from the detector group should be charged with the responsibility of gathering together a group of detectors that can be used to determine the adequacy of the EPS electronics. Spahn and Cash understand the necessary ramifications involved in the selection of detectors.

It is also my recommendation that we should obtain the use of the MSC Van de Graaff. Since we have no scattering chamber, beam profile measuring apparatus, or beam monitoring equipment, the use of another facility, such as the one available at Rice, for this testing would be very painful and possibly impossible. Due to schedule and manpower limitations, we should attempt to gain access for the last two weeks in January. I have seen a NASA/MSC Action Document from the Space Physics Division Chief giving access to the Van de Graaff to GE during this period. The Van de Graaff is scheduled to close on February 1, 1971.

R. S. Lindsey Jr
R. S. Lindsey

cc: Cash
Curtsinger
Lyons
Oliveira
O'Neill
Spahn

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./673-10 BLDG./Beta PLANT/HASD DATE 12-29-70
ORGN. ZONE FAC. Ref: EPS-89

FROM R. S. Lindsey

DEPT./673-10 BLDG./Beta PLANT/HASD EXT. 422
ORGN. ZONE FAC.

SUBJECT: Selection of EPS Post Amplifier Time Constants

In IDC EPS-86 of 12-28-70, preliminary recommendations for post amplifier time constants were made. These were based upon sketchy information available at that time. On 12-28-70, Bob O'Neill repeated the data very carefully. The results are included here. Indications are that it is possible to operate the post amplifiers at time constants equal to the worst case charge collection times and suffer no ill effects so long as the worst case charge collection times are true. This would imply time constants of 110 nsec and 361 nsec for the (1 mm)³ and (2 mm)³ detector channels respectively. These time constants would produce dead times of 33% and 108% at input rates of 250K/sec. I recommend the following:

- A. Accurately breadboard time constants of 110 nsec and 361 nsec and repeat the Relative Gain Charge Collection Time Data in a manner equal in precision to that reported here. Since the curves roll off more slowly as the time constant increases it might be possible to reduce the time constants by a small amount as a result of analyzing the 110 nsec, 361 nsec data. Accurately measure the post amplifier output wave shape to assume the proper time constant.
- B. Generate counting rate information for each channel based upon the EPS boundaries and a Starfish Electron Enhancement.
- C. Using the Random Pulser examine the behavior of the pre-amplifier - post amplifier - pulse height discriminator combination as a function of random input rate to determine whether or not EPS can be paralyzed by high counting rate conditions. If paralysis is possible its manner of onset and rate location are central to the quality of EPS and should be well known.

R. S. Lindsey
R. S. Lindsey

cc: Cash
Curtsinger
Lyons
Oliveira
O'Neill

INTERDEPARTMENTAL COMMUNICATION

TO B. C. Hall

DEPT./673-10 BLDG./ Beta PLANT/ HASD DATE 12-28-70
ORON. ZONE FAC. Ref: EPS-86

FROM R. S. Lindsey

DEPT./673-10 BLDG./ Beta PLANT/ HASD EXT. 422
ORON. ZONE FAC.

SUBJECT: Selection of EPS Post Amplifier Time Constants

To optimize the EPS linear electronics performance for high counting rate conditions, it is necessary to minimize the time required to process each detected event. This is accomplished by minimizing the post amplifier characteristic time constant (τ). The concept of EPS requires that the post amplifier output pulse height be proportional to the total charge generated within the detector during an event. This implies that τ is long with respect to the time necessary to collect the generated charge (T). It is apparent from a knowledge of the required counting rates and the proposed charge collection times that a conflict is possible. The facts necessitate a detailed analysis of both the charge collection time and its interaction with the post amplifier time constant.

The charge collection time for a carrier is given by:

$$T = \frac{d^2}{\mu V}$$

Since μ_H (the hole mobility) is approximately a factor of two less than μ_e (the electron mobility), calculations will be based upon times for holes. Now:

$$T_H = \frac{d^2}{\mu_H V}$$

where: T is the hole collection time
 d is the depletion depth in cm
 μ_H is the hole mobility in $\text{cm}^2/\text{volt-sec}$
 V is the depletion bias in volts.

Additionally:

$$\mu_H = 2.3 \times 10^9 t^{-2.7}$$

where: t is the temperature in ° Kelvin.

Energy loss requirements have already fixed the nominal values of d at 1 mm and 2 mm. The worst case value of μ_H occurs when t is maximized. Under operational conditions this is defined as $0^\circ\text{C} = 273^\circ\text{K}$. However, since checkout of the instrument is necessary at up to $+30^\circ\text{C} = 103^\circ\text{K}$, the true worst case value of μ_H occurs here. These two mobility values are:

$$\mu_H(0^\circ\text{C}) = 608 \text{ cm}^2/\text{volt-sec}$$

$$\mu_H(+30^\circ\text{C}) = 459 \text{ cm}^2/\text{volt-sec.}$$

Worst case initial depletion depth errors have been investigated by Spahn and Cash. Solid State Radiation, Inc. guarantees an initial error of $\leq \pm 15\%$ of nominal depletion depth.

Depletion depth drift as a function of oxygen impurity level, time, temperature and detector bias has been the subject of a detailed study by Spahn. He reports very little data to be available with poor agreement between authors. The worst case depletion depth drift calculations are conservative and assume an MDA mounting with the following conditions:

- A. 350° volts detector bias
- B. A .38 year active detector mission
- C. A constant 0°C detector temperature.

Spahn has proposed some additional experimental work to verify his findings.

The proposed values for detector bias were a compromise resulting from problems with voltage derating of detectors, high voltage corona effects and the complexity of dual supplies. A value of 350 volts has been selected.

Figure 1 summarizes all these effects and the resulting hole collection time.

In parallel with this effort it is possible to measure the effect of finite charge collection time on post amplifier output pulse height to determine what τ is suitable for a known T_H . This work was done by Bob O'Neill on December 24, 1970, using hypothetical values of τ near the final EPS values. These data, Figures 2 and 3, relate the post amplifier output amplitude to the ratio of charge collection time (T) to post amplifier time constant (τ). Several things are clear from these data, and are:

1. The $\tau = 276$ nsec data should be repeated to remove several ambiguities that exist near the critical value of T/τ .
2. The $\tau = 83$ nsec data should be extended on the lower side to a point where the post amplifier output amplitude shows no further increase.
3. If a decision must be reached from these data for maximum acceptable T/τ values the result would be ≤ 0.5 .
4. When preliminary values are established for τ (1 mm) and τ (2 mm) detailed precision data should be repeated for the exact values. This process should be repeated until acceptable values are found.
5. A computer program to predict the interaction between T, τ and the output amplitude should be generated on a reduced priority basis to allow a finer analysis of the problem. The two measured boundary values should be checked to insure the program's accuracy.

To sum up, on the basis of data available now, time constants of 220 nsec for the (1 mm)³ detector and 722 nsec for (2 mm)³ detectors are necessary, resulting in pile-ups of 66% and 217% respectively at input rates of 250,000/sec. Shorter time constants could result in an inability to claim equality between instruments due to detector variations. Better information from O'Neill could possibly lower the time constants.

R. S. Lindsey Jr
R. S. Lindsey

Atch: Figures 1, 2 and 3

cc: Cash	Oliveira	
Curtsinger	O'Neill	152
Lyons	Spahn	

FIGURE 1
HOLE COLLECTION TIMES FOR EPS

			Charge Collection Time	
			0°C	+30°C
(1 mm) ³	Nominal Depletion Depth	(1.00 mm)	48 nsec	63 nsec
	Maximum Initial Depletion Depth	(1.15 mm)	63 nsec	84 nsec
	Maximum Drifted Depletion Depth	(1.32 mm)	83 nsec	110 nsec
(2 mm) ³	Nominal Depletion Depth	(2.00 mm)	192 nsec	255 nsec
	Maximum Initial Depletion Depth	(2.30 mm)	254 nsec	337 nsec
	Maximum Drifted Depletion Depth	(2.38 mm)	272 nsec	361 nsec

$$T_H = \frac{d}{H V} = \frac{d}{2.3 \times 10^9 t^{-2.7} V}$$

- Assumptions:
1. The maximum acceptable leakage current for a 1 mm³ detector at 30°C is 1 μ amp resulting in a bias voltage loss of 2.22 volts
 2. The maximum acceptable leakage current for a 2 mm³ detector at 30°C is 2 μ amp resulting in a bias voltage loss of 4.44 volts.
 3. The minimum bias voltage supply value is 347.7 volts.
 4. Depletion depth drift values are calculated assuming an MDA mounting with a maximum temperature of 0°C.

Figure 2

DEC 27, 1970

RELATIVE POST AMPLIFIER GAIN →

154

$\tau = 83 \text{ Nsec}$
EPS PREAMP
EPS POST AMP

CHARGE COLLECTION TIME / POST AMPLIFIER TIME CONSTANT (τ/τ) →

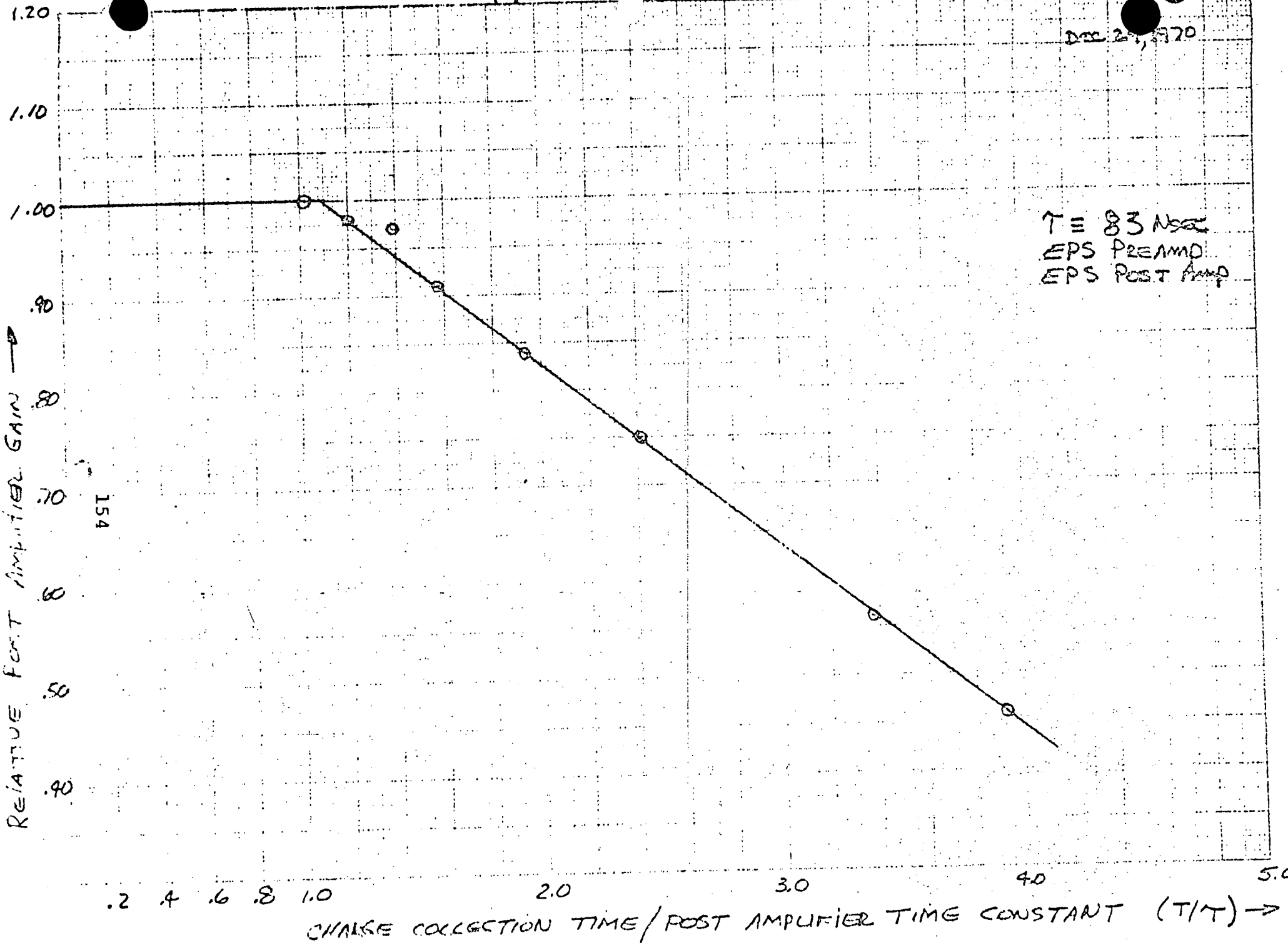


FIGURE 3

Dec 29, 1972

RELATIVE POST AMPLIFIER OUTPUT

1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40

155

0.2 0.4 0.6 0.8 1.0

2.0

3.0

4.0

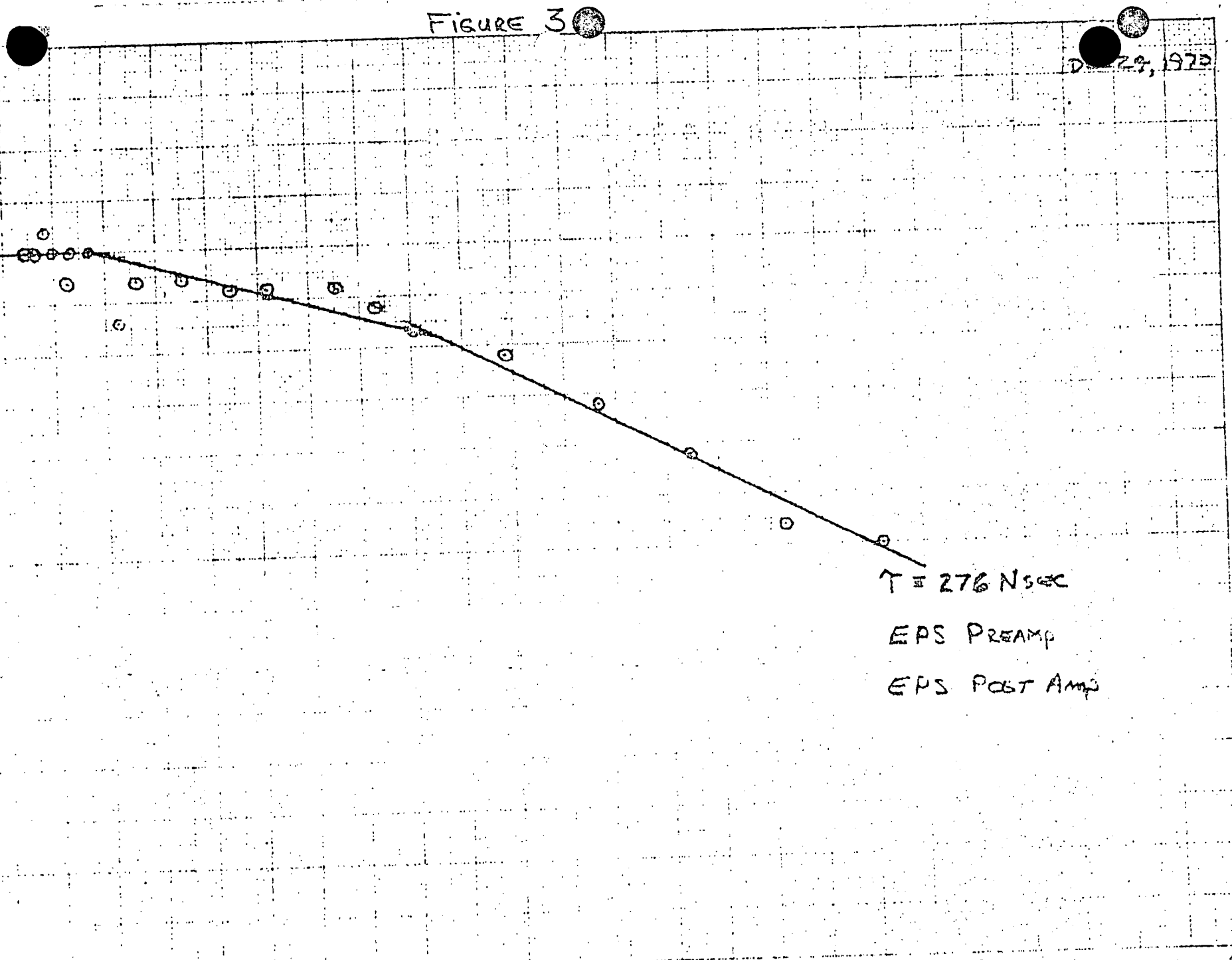
5.0

CHARGE COLLECTION TIME / POST AMPLIFIER TIME CONSTANT (τ/τ) →

$\tau = 276 \text{ NSEC}$

EPS PREAMP

EPS POST AMP



EPS AMPLIFIER

An Analysis of the Filter Configuration and the Optimization of Signal Shapes

This report will discuss a pulse shaping amplifier composed of two sections of active filtering using two operational amplifiers connected in the inverting configuration, with bridged tee RC networks for the feedback branches. Two cases will be considered: (1) the output pulse is unipolar in nature, and (2) the output pulse is bipolar.

The design is conducted with the purpose of achieving optimum performance from the filters in regard to minimum noise contribution and predictable pulse shapes; that is, the unipolar pulse shall be near Gaussian with no undershoot, exhibiting almost perfect symmetry between the rise and fall times, and the bipolar pulse shall exhibit only one baseline crossover and its total duration being approximately equal to the unipolar pulse.

Unipolar Configuration

In order to study the response of the filter to the signal coming from the charge sensitive preamplifier, consider the circuit shown in Figure 1:

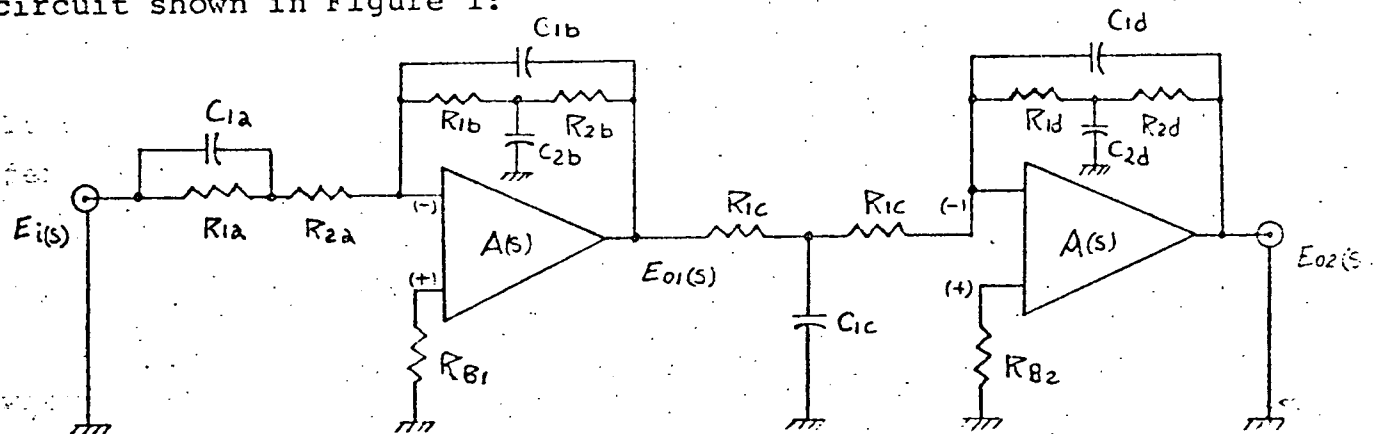


Figure 1

It will later become apparent that this configuration corresponds to unipolar shaping provided that the filter elements are chosen accordingly.

The signal coming from the preamplifier into the amplifier's input can be expressed as

$$e_i(t) = \frac{Q}{C_f} e^{-\frac{t}{\tau}} \quad (1)$$

where:

$Q \rightarrow$ signal charge at the preamplifier's input.

$C_f \rightarrow$ preamplifier's feedback capacitor.

$\tau \rightarrow R_f \times C_f =$ preamplifier signal decay time constant and R_f is a high valued resistor connected across C_f .

In the complex frequency domain, equation (1) becomes:

$$E_i(s) = \frac{Q}{C_f} \frac{1}{s + \frac{1}{\tau}} \quad (2)$$

Let us now compute the transfer function of the amplifier's first filter section. That will consist of evaluating the ratio

$$\frac{E_{01}(s)}{E_i(s)}$$

It can be shown by operational amplifier theory that this transfer function is given by

$$\frac{E_{01}(s)}{E_i(s)} = \frac{-Y_{21a}}{Y_{21b}} \quad (3)$$

where Y_{21a} , Y_{21b} are the transadmittances of the input and feedback networks respectively.

Using standard network analysis techniques, Y_{21a} is found to be:

$$Y_{21a} = \frac{1}{R_{2a}} \frac{s + \frac{1}{R_{1a}C_{1a}}}{s + \frac{1}{\frac{R_{1a}R_{2a}}{R_{1a} + R_{2a}} \times C_{1a}}} \quad (4)$$

and:

$$-Y_{21b} = \frac{C_{1b}}{\left(s + \frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right)} \left[s^2 + \left(\frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right) s + \frac{1}{R_{1b}C_{1b}R_{2b}C_{2b}} \right] \quad (5)$$

and the transfer function is given by:

$$\frac{E_{01}(s)}{E_i(s)} = \frac{\frac{1}{R_{2a}} \left(s + \frac{1}{R_{1a}C_{1a}} \right)}{\frac{C_{1b}}{\left(s + \frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right)} \left[s^2 + \left(\frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right) s + \frac{1}{R_{1b}C_{1b}R_{2b}C_{2b}} \right]} \quad (6)$$

Recalling equation (2), and establishing the condition that $\tau = R_f \times C_f$ be equal to $R_{1a} \times C_{1a}$, one finds that upon multiplication of the preamplifier output response to the network "a" transfer function, there is a pole-zero cancellation and the response at the output of the first amplifier is given by:

$$E_{01}(s) = - \frac{\frac{Q}{C_f} \times \frac{1}{\left(s + \frac{1}{\frac{R_{1a} \times R_{2a}}{R_{1a} + R_{a1}} C_{1a}} \right)}}{R_{2a}C_{1b} \left[s^2 + \left(\frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right) s + \frac{1}{R_{1b}C_{1b}R_{2b}C_{2b}} \right] \left(s + \frac{1}{\frac{R_{1b}R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right)} \quad (7)$$

It is desirable to have the differentiating time constant of the input network equal to the integrating time constant of the bridged tee network and thus superimpose the pole of Y_{21a} with the pole of Y_{21b} . Once this is established, $E_{01}(s)$ becomes:

$$E_{01}(s) = - \frac{Q}{C_f R_{2a} C_{1b}} \frac{1}{\left[s^2 + \left(\frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \right) s + \frac{1}{R_{1b} C_{1b} R_{2b} C_{2b}} \right]} \quad (8)$$

Equation (8) gives the signal response at the output of the first operational amplifier.

By studying the locations of the poles of $E_1(s)$, one can determine the nature of the time response or pulse behavior. It will, of course, depend on the roots of the characteristic equation:

$$s^2 + 2 \rho W_0 s + W_0^2 = 0 \quad (9)$$

where the new variables are:

$$W_0^2 = \frac{1}{R_{1b} C_{1b} \cdot R_{2b} C_{2b}} \quad (10)$$

and

$$2 \rho W_0 = \frac{1}{\frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b}} \quad (11)$$

Solving for ρ in equation (9) one finds:

$$\rho = \frac{1}{2 \times \frac{R_{1b} \times R_{2b}}{R_{1b} + R_{2b}} C_{2b} \times \frac{1}{\sqrt{R_{1b} C_{1b} \cdot R_{2b} C_{2b}}}}$$

$$\rho = \frac{(R_{1b} + R_{2b}) \sqrt{R_{1b} C_{1b} \cdot R_{2b} C_{2b}}}{2 R_{1b} \cdot R_{2b} C_{2b}} \quad (12)$$

The roots of equation (9) are:

$$s_{1,2} = \frac{-2\rho W_0 \pm \sqrt{4\rho^2 W_0^2 - 4W_0^2}}{2}$$

or

$$s_{1,2} = \frac{2\rho W_0 \pm 2W_0 \sqrt{\rho^2 - 1}}{2} \quad (13)$$

Equation (13) tells that one can expect three different kinds of solutions depending on the value of the parameter ρ .

$\rho < 1$, $s_{1,2}$ will be a pair of complex conjugates in the left half of the complex frequency plane. In this case the response of equation (8) will be underdamped and will present oscillations.

$\rho > 1$, $s_{1,2}$ will be two numbers located on the negative real axis of the complex frequency plane. In this case the response of the equation (8) will be overdamped.

$\rho = 1$, $s_{1,2}$ will be a pair of coincident real roots located on the negative real axis of the complex frequency plane. In this case, the response of equation (8) will be critically damped. This means, fastest return to the baseline with no oscillations.

In the present application, one is more interested in this third type of solution ($\rho = 1$) which gives for solutions the following:

$$s_{1,2} = W_0(2)$$

Under these conditions, equation (8) can be rewritten as:

$$E_{01}(s) = \frac{\frac{Q}{C_f R_{2a} C_{1b}}}{\left(s + \frac{1}{\sqrt{R_{1b} C_{1b} R_{2b} C_{2b}}}\right)^2} \quad (14)$$

For the second stage of filtering, the transfer function is again given by:

$$\frac{E_{02}(s)}{E_{01}(s)} = - \frac{Y_{21c}}{Y_{21d}}$$

It is easily shown that:

$$Y_{21c} = \frac{\frac{1}{(R_{1c})^2 C_{1c}}}{s + \frac{2}{(R_{1c})^2 C_{1c}}} \quad (15)$$

and

$$Y_{21d} = - \frac{C_{1d} \left[s^2 + \left(\frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d}} C_{2d} \right) s + \frac{1}{R_{1d} R_{2d} C_{1d} C_{2d}} \right]}{\left(s + \frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d}} C_{2d} \right)} \quad (16)$$

Thus:

$$\frac{E_{02}(s)}{E_{01}(s)} = - \frac{\frac{1}{(R_{1c})^2 C_{1c}} / \left(s + \frac{2}{(R_{1c})^2 C_{1c}} \right)}{C_{1d} \left[s^2 + \left(\frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d}} C_{2d} \right) s + \frac{1}{R_{1d} R_{2d} C_{1d} C_{2d}} \right] \left(s + \frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d}} C_{2d} \right)} \quad (17)$$

In this case, if the pole of Y_{21c} is made to coincide with the pole of Y_{21d} , one has:

$$\frac{E_{02}(s)}{E_{01}(s)} = \frac{\frac{1}{(R_{1c})^2 C_{1c}}}{C_{1d} \left[s^2 + \frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d} C_{2d}} s + \frac{1}{R_{1d} R_{2d} C_{1d} C_{2d}} \right]} \quad (18)$$

and the condition used to obtain (18) was:

$$\frac{R_{1c}}{2} \times C_{1c} = \frac{R_{1d} \times R_{2d}}{R_{1d} + R_{2d}} \times C_{2d} \quad (19)$$

The output voltage response will be obtained by multiplying both members of equation (18) by $E_{01}(s)$ and then substituting $E_{01}(s)$ by its expression as given by equation (14). Thus:

$$E_{02}(s) = \frac{Q}{C_f R_{2a} C_{1b} C_{1d} (R_{1c})^2 C_{1c}} \left[s^2 + \frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d} C_{2d}} s + \frac{1}{R_{1d} R_{2d} C_{1d} C_{2d}} \right] \left[s + \frac{1}{\sqrt{R_{1b} C_{1b} R_{2b} C_{2b}}} \right] \quad (20)$$

The second filter section can also have its elements chosen so as to guarantee critically damped response. Under these conditions, one has:

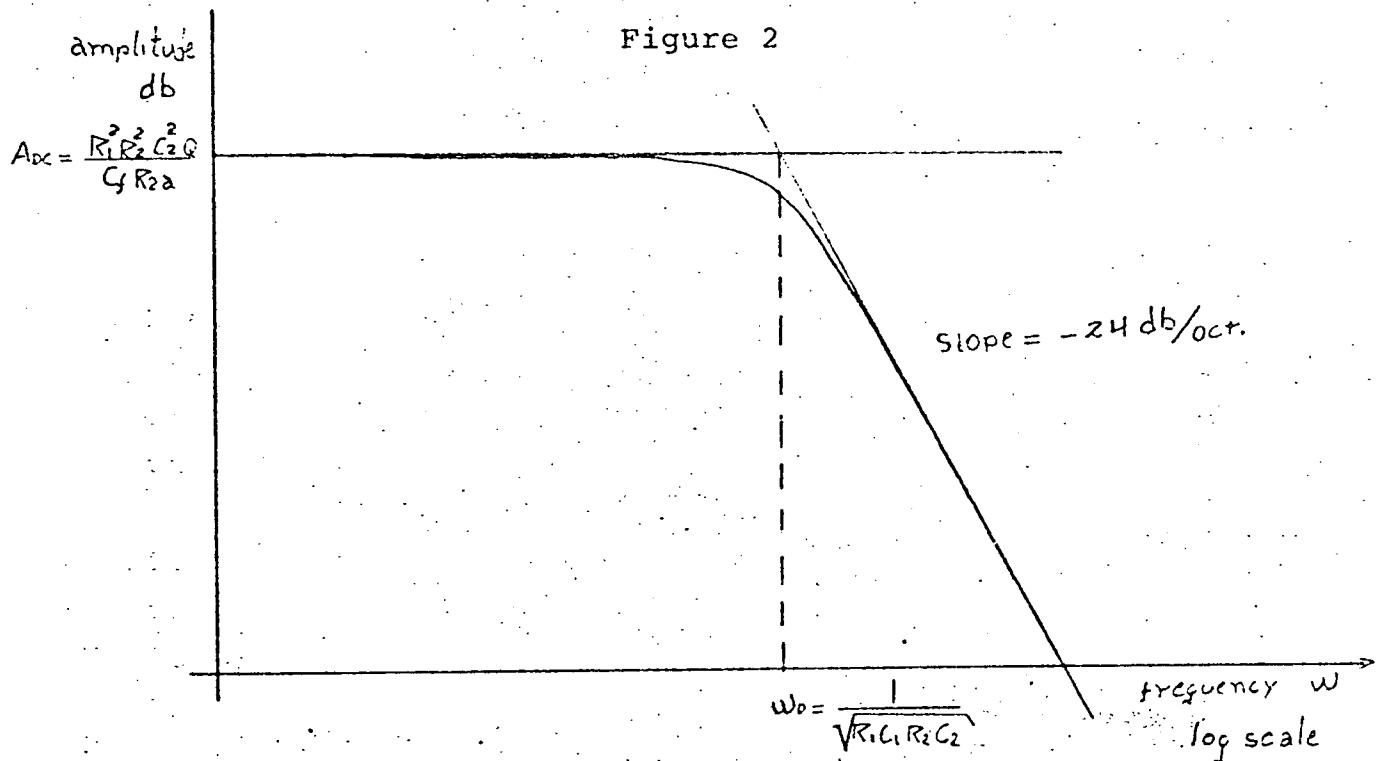
$$E_{02}(s) = \frac{Q}{C_f R_{2a} C_{1b} C_{1d} (R_{1c})^2 C_{1c}} \left[s + \frac{1}{\sqrt{R_{1d} C_{1d} R_{2d} C_{2d}}} \right]^2 \left[s + \frac{1}{\sqrt{R_{1b} C_{1b} R_{2b} C_{2b}}} \right]^2 \quad (21)$$

If one goes one step further and makes the bridged tee elements for both filters correspondingly, equal, Equation (21) becomes:

$$E_{02}(s) = \frac{Q}{C_f R_{2a} C_{1d}^2 (R_{1c})^2 C_{1c}} \left[s + \frac{1}{\sqrt{R_1 C_1 R_2 C_2}} \right]^4 \quad (22)$$

Equation (22) gives the overall response of the pulse shaping amplifier when fed from a charge sensitive preamplifier. The filtering is arranged so that there is one early differentiation at the "front end" in the so-called "pole-zero" cancellation network, followed by two stages of active integration. In addition, the time constants were chosen to be equal as explained above.

The frequency domain amplitude response is shown in figure 2 below.



The time domain expression for equation (22) is given by:

$$e_{02}(t) = \frac{Q}{C_f R_{2a} C_1^2 (R_{1c})^2 C_{1c}} \times \frac{1}{6} t^3 e^{\frac{-t}{\sqrt{R_1 C_1 R_2 C_2}}} \quad (23)$$

where $\sqrt{R_1 C_1 R_2 C_2} = \tau$ is the time constant.

The time for $e_{02}(t)$ to reach its maximum amplitude can be found by taking the derivative of $e_{02}(t)$ with respect to time, equating it to zero and solving the resulting equation:

$$\frac{de_{02}(t)}{dt} = K_1 \frac{1}{6} t^3 - \frac{1}{\tau} e^{-\frac{t}{\tau}} + K_1 \times \frac{1}{6} e^{-\frac{t}{\tau}} \times 3t^2 = 0 \quad (24)$$

thus:

$$-\frac{t}{\tau} + 3 = 0$$

and $t = 3\tau$.

(25)

Expression (23) can be normalized with respect to amplitude and time constant, resulting in the following expression:

$$e_{02}(t) = t^3 e^{-t} \quad (26)$$

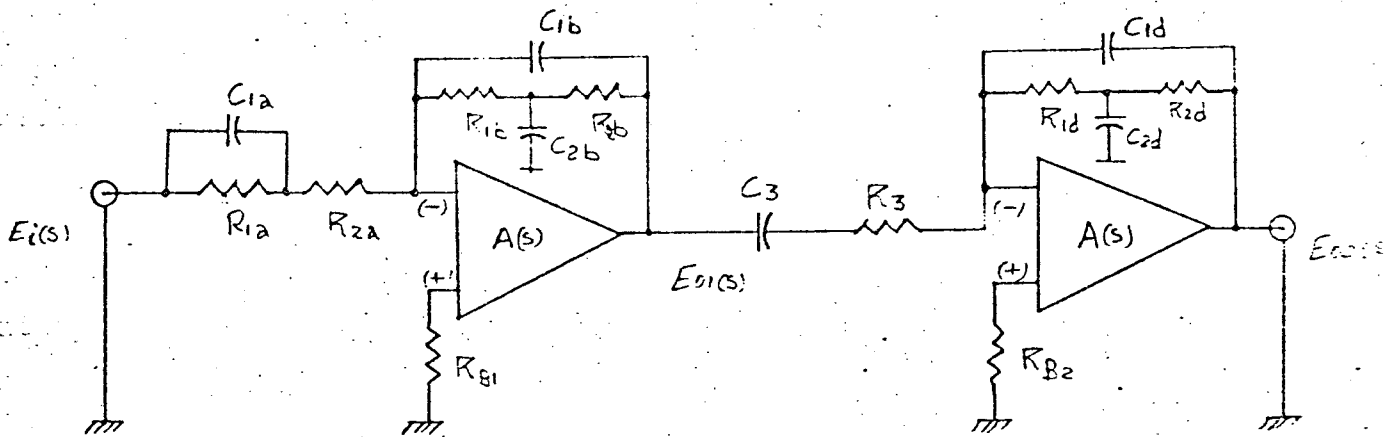
Examining expression (26) one immediately concludes that $e_{02}(t)$ has two singularities, that is, its value is zero for $t = 0$ and also for $t = \infty$. This, of course, clearly identifies the strictly unipolar nature of this amplifier configuration.

It is desirable to know the values of $e_{02}(t)$ for many different values of t in order to have a clear understanding of the system "dead-time" and "pile-up" effects under high pulse rate excitation. The expression $e_{02}(t) = t^3 e^{-t}$ was solved for t in increments of $\Delta t = .1$ from $t = 0$ to $t = 20$, using the H.P. 9100B calculator, and the results are presented in the form of a table of $e_{02}(t)$ versus t and also in the form of a plot of $e_{02}(t)$ versus t . The plot has been normalized so that maximum amplitude is made equal to 1. This allows all the other points to be immediately viewed as a direct percentage of the maximum value. The table and the plot are shown in figures 5 and 8 respectively.

Bipolar Configuration

In order to achieve a bipolar pulse response at the output of the shaping amplifier, it is necessary to differentiate the incoming pulse twice. For this particular application, and due to loading considerations, it is preferable to place the second differentiator between the two operational amplifiers. This can be made of a series R-C network at the input section of the second active filter as shown in figure 3.

Figure 3



By comparing figure 3 with figure 1, it becomes apparent that $E_{o1}(s)$ still has the same expression as given by equation (14). Furthermore, the transmittance of the second amplifier feedback network will also be maintained unchanged and equal to equation (16). Thus:

$$Y_{21d} = - \frac{C_{1d} \left[s^2 + \left(\frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d} C_{2d}} \right) s + \frac{1}{(R_{1d} C_{1d} R_{2d} C_{2d})} \right]}{\left(s + \frac{R_{1d} + R_{2d}}{R_{1d} \times R_{2d} C_{2d}} \right)} \quad (16)$$

The second stage input network transmittance will be:

$$Y_{21} = \frac{1}{R_3} \times \frac{S}{S + \frac{1}{R_3 C_3}} \quad (27)$$

and the second filter transfer function is given by:

$$\frac{E_{02}(s)}{E_{01}(s)} = - \frac{\frac{1}{R_3} \frac{S}{S + \frac{1}{R_3 C_3}}}{C_1 \left[s^2 + \left(\frac{R_1 + R_2}{R_1 R_2 C_2} \right) s + \frac{1}{R_1 C_1 R_2 C_2} \right] \left(s + \frac{R_1 + R_2}{R_1 R_2 C_2} \right)} \quad (28)$$

As in the unipolar case, it is advantageous to make the following equality:

$$R_3 C_3 = \frac{R_1 R_2}{R_1 + R_2} C_2 \quad (29)$$

Under this condition, equation (18) becomes:

$$\frac{E_{02}(s)}{E_{01}(s)} = - \frac{S}{R_3 C_1 \left[s^2 + \left(\frac{R_1 + R_2}{R_1 R_2 C_2} \right) s + \frac{1}{R_1 C_1 R_2 C_2} \right]} \quad (30)$$

By using $E_{01}(s)$ as given by equation (14) and considering critical damping for expression (30), the output response becomes:

$$E_{02}(s) = \left(\frac{Q}{R_3 C_f R_2 a C_1^2} \right) \times \frac{S}{\left[s + \frac{1}{\sqrt{R_1 C_1 R_2 C_2}} \right]^4} \quad (31)$$

By studying equation (31) it can be seen that the effect of a second differentiation is the addition of a zero located at the origin. The time domain expression for equation (31) is given by:

$$E_{02}(t) = K_1 \times \frac{1}{2} \times e^{-\frac{t}{\tau}} \left(t^2 - \frac{1}{3\tau} t^3 \right) \quad (32)$$

$$\text{where } K_1 = \frac{Q}{R_3 C_f R_{2a} C_1^2}$$

$$\text{and } \tau = \sqrt{R_1 C_1 R_2 C_2}$$

The times to reach the positive and negative peaks can be found by taking the derivative of $e_{02}(t)$ with respect to t , equating it to zero and then solving for t . After some straightforward manipulations, the following equation results:

$$t^2 - 6\tau t + 6\tau^2 = 0 \quad (33)$$

for which the two solutions $t_1 = 1.27\tau$ and $t_2 = 4.73\tau$ are respectively the times of the first and second peaks of the bipolar pulse.

By substituting the values $t_1 = 1.27\tau$ and $t_2 = 4.73\tau$ into expression (32) the peak values of $e_{02}(t)$ are found to be:

$$e_{02}(\text{first peak}) = + \frac{.262 \times K_1}{2} \quad (34)$$

$$e_{02}(\text{second peak}) = - \frac{.114 \times K_1}{2} \quad (35)$$

It is interesting to know that:

$$\frac{e_{02}(\text{second peak})}{e_{02}(\text{first peak})} = \frac{.114}{.262} = .435 \quad (36)$$

This means that the secondary lobe of the bipolar pulse has a peak that is only 43.5% as big as the primary lobe peak. However, the areas under these two lobes should be equal.

In order to find the time for the bipolar pulse to cross the baseline, one makes expression (32) equal to zero and then solve the resulting equation for t . Once that is done, the crossover point is found to be at:

$$t = 3\tau \quad (37)$$

As in the case of the unipolar pulse analysis, expression (32) can be normalized with respect to amplitude and time constant, so that the following expression results:

$$e_{02}(t)_N = e^{-t} \left(\tau^2 - \frac{t^3}{3} \right) \quad (38)$$

This expression was also solved for t , in increments of $\Delta t = .1$ from $t = 0$ to $t = 20$, using the H.P. 9100B calculator. The results are presented in the form of a table in figure 9 and of a plot in figure 6.

The frequency domain amplitude response for the bipolar pulse, corresponding to expression (31), is shown in the figure below.

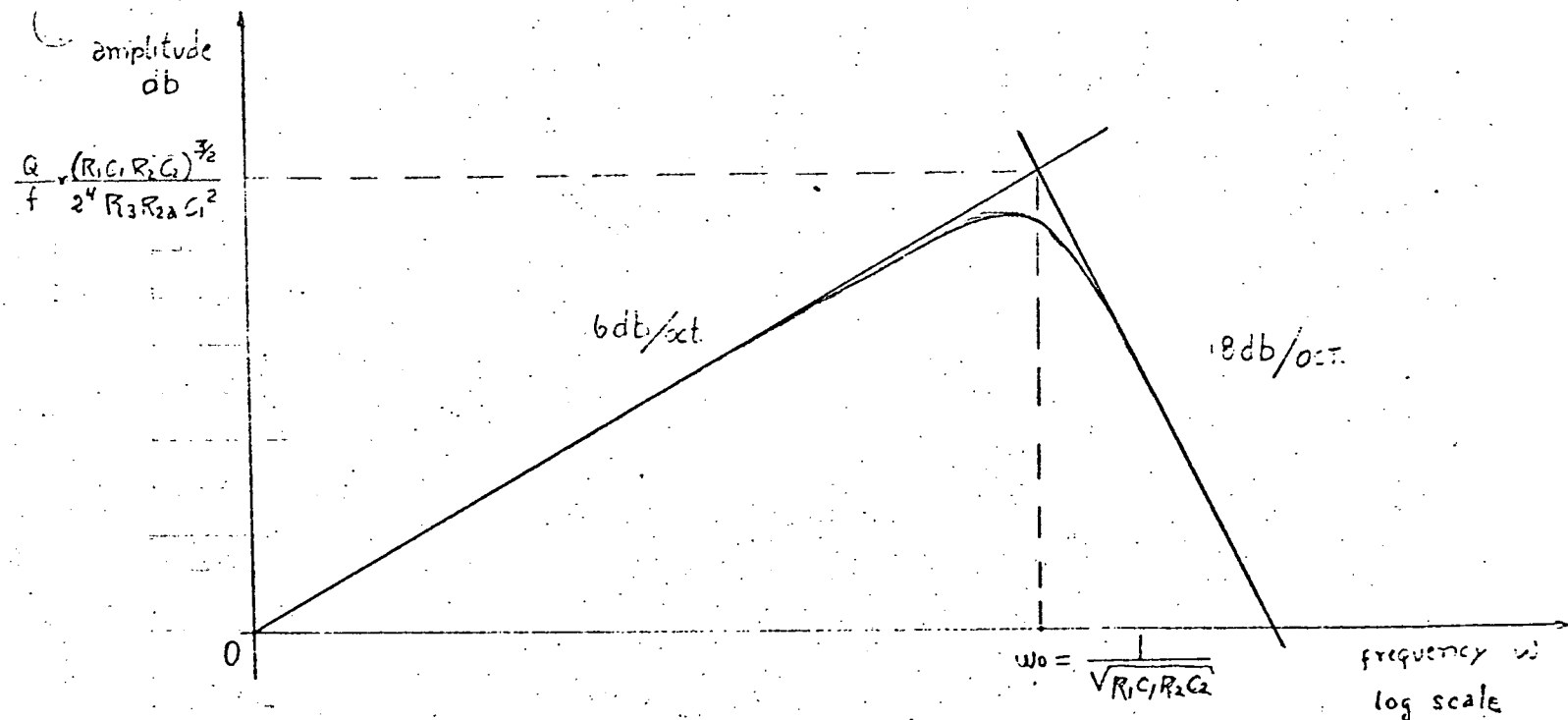


Figure 4

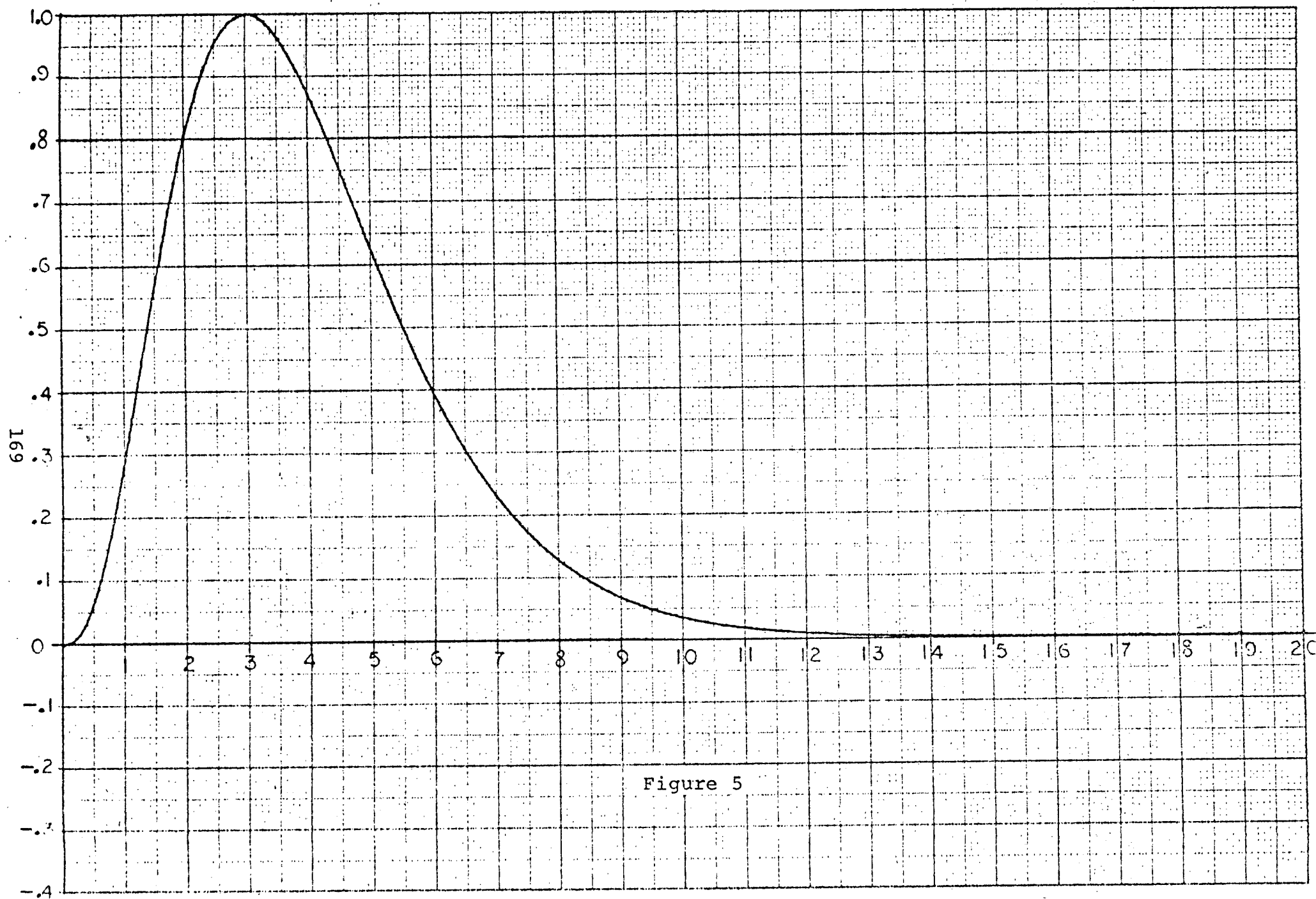


Figure 5

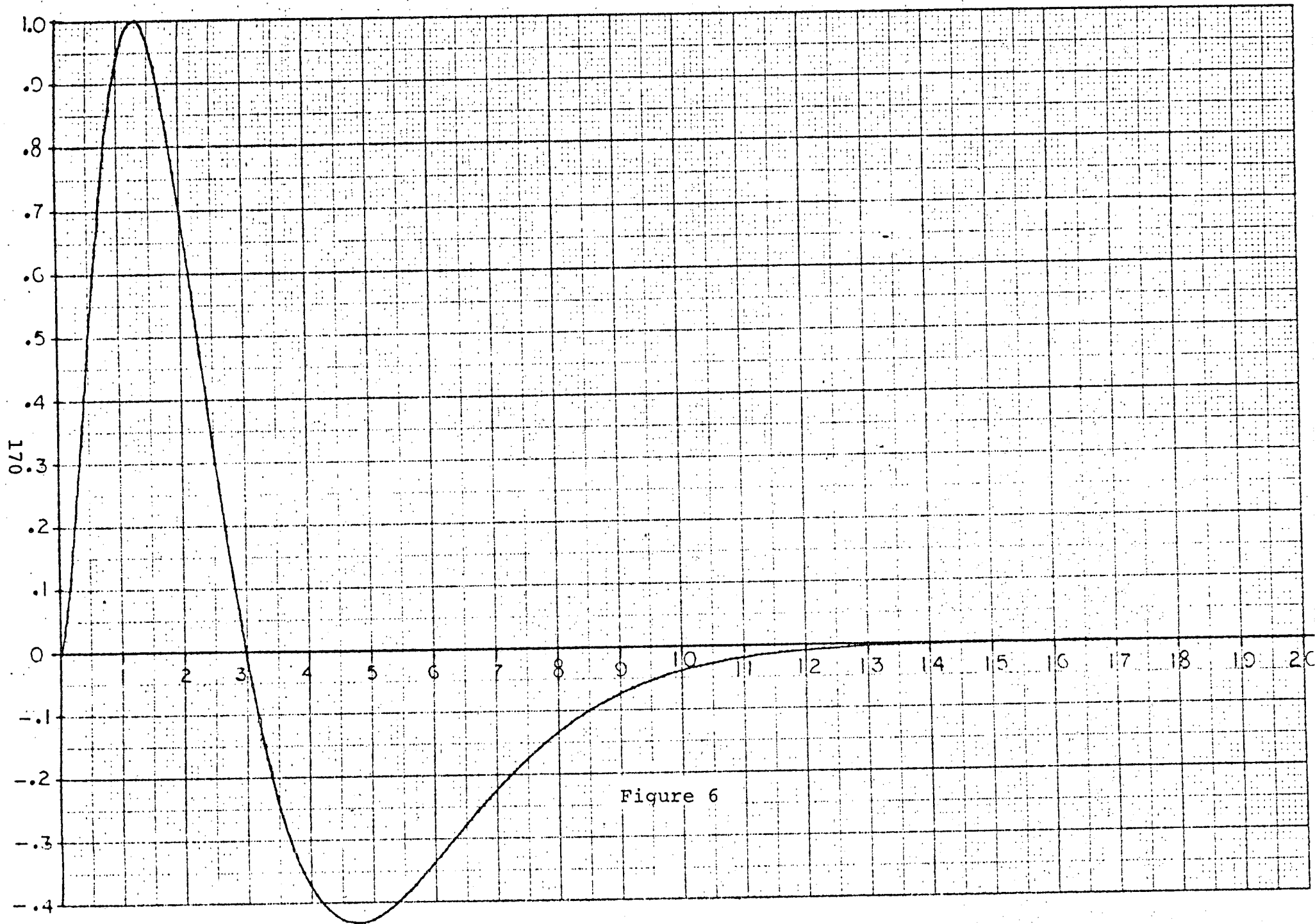


Figure 6

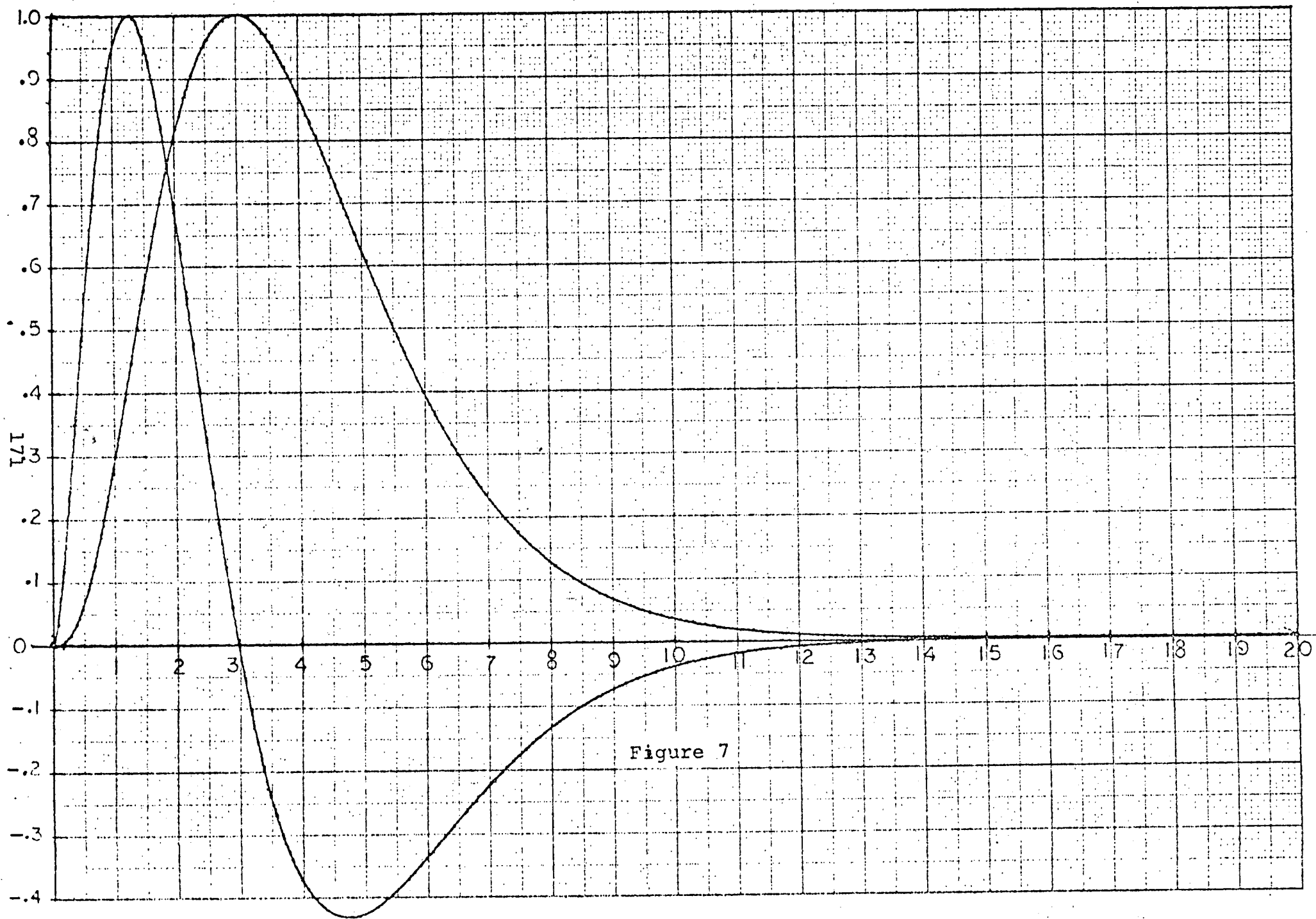


Figure 7

Figure 8
UNIPOLAR SHAPING

t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$
0.1	.0006	3.1	.9984	6.1	.3787	9.1	.0626	12.1	.0073
0.2	.0048	3.2	.9937	6.2	.3598	9.2	.0585	12.2	.0067
0.3	.0148	3.3	.9861	6.3	.3416	9.3	.0547	12.3	.0063
0.4	.0319	3.4	.9759	6.4	.3240	9.4	.0511	12.4	.0058
0.5	.0564	3.5	.9632	6.5	.3071	9.5	.0477	12.5	.0054
0.6	.0881	3.6	.9484	6.6	.2909	9.6	.0445	12.6	.0050
0.7	.1267	3.7	.9317	6.7	.2754	9.7	.0416	12.7	.0046
0.8	.1711	3.8	.9132	6.8	.2605	9.8	.0388	12.8	.0043
0.9	.2205	3.9	.8933	6.9	.2463	9.9	.0362	12.9	.0039
1.0	.2737	4.0	.8721	7.0	.2327	10.0	.0337	13.0	.0036
1.1	.3296	4.1	.8498	7.1	.2197	10.1	.0314	13.1	.0034
1.2	.3872	4.2	.8265	7.2	.2073	10.2	.0293	13.2	.0031
1.3	.4454	4.3	.8026	7.3	.1955	10.3	.0273	13.3	.0029
1.4	.5034	4.4	.7781	7.4	.1842	10.4	.0254	13.4	.0027
1.5	.5602	4.5	.7531	7.5	.1735	10.5	.0237	13.5	.0025
1.6	.6152	4.6	.7279	7.6	.1634	10.6	.0220	13.6	.0023
1.7	.6677	4.7	.7025	7.7	.1538	10.7	.0205	13.7	.0021
1.8	.7172	4.8	.6771	7.8	.1446	10.8	.0191	13.8	.0019
1.9	.7632	4.9	.6518	7.9	.1359	10.9	.0177	13.9	.0018
2.0	.8055	5.0	.6266	8.0	.1277	11.0	.0165	14.0	.0016
2.1	.8437	5.1	.6017	8.1	.1200	11.1	.0153	14.1	.0015
2.2	.8777	5.2	.5771	8.2	.1126	11.2	.0142	14.2	.0014
2.3	.9075	5.3	.5528	8.3	.1057	11.3	.0132	14.3	.0013
2.4	.9330	5.4	.5291	8.4	.0991	11.4	.0123	14.4	.0012
2.5	.9542	5.5	.5058	8.5	.0929	11.5	.0114	14.5	.0011
2.6	.9712	5.6	.4831	8.6	.0871	11.6	.0106	14.6	.0010
2.7	.9841	5.7	.4610	8.7	.0816	11.7	.0098	14.7	.0009
2.8	.9931	5.8	.4394	8.8	.0764	11.8	.0091	14.8	.0009
2.9	.9984	5.9	.4185	8.9	.0715	11.9	.0085	14.9	.0008
3.0	1.0001	6.0	.3983	9.0	.0669	12.0	.0078	15.0	.0007

Figure 9
BIPOLAR SHAPING

t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$	t	$\frac{e_{02} \times 100\%}{e_{02}^{\max}}$
0.1	.0335	3.1	.0552	6.1	.3304	9.1	.0720	12.1	.0094
0.2	.1171	3.2	.1066	6.2	.3188	9.2	.0677	12.2	.0087
0.3	.2299	3.3	.1539	6.3	.3072	9.3	.0636	12.3	.0081
0.4	.3561	3.4	.1971	6.4	.2955	9.4	.0597	12.4	.0076
0.5	.4842	3.5	.2362	6.5	.2839	9.5	.0560	12.5	.0070
0.6	.6056	3.6	.2713	6.6	.2724	9.6	.0526	12.6	.0065
0.7	.7148	3.7	.3026	6.7	.2611	9.7	.0493	12.7	.0060
0.8	.8081	3.8	.3300	6.8	.2499	9.8	.0462	12.8	.0056
0.9	.8833	3.9	.3539	6.9	.2390	9.9	.0433	12.9	.0052
1.0	.9398	4.0	.3743	7.0	.2282	10.0	.0405	13.0	.0048
1.1	.9775	4.1	.3914	7.1	.2178	10.1	.0380	13.1	.0045
1.2	.9972	4.2	.4054	7.2	.2076	10.2	.0355	13.2	.0042
1.3	1.0001	4.3	.4165	7.3	.1977	10.3	.0332	13.3	.0038
1.4	.9877	4.4	.4250	7.4	.1881	10.4	.0311	13.4	.0036
1.5	.9619	4.5	.4310	7.5	.1788	10.5	.0290	13.5	.0033
1.6	.9242	4.6	.4346	7.6	.1698	10.6	.0271	13.6	.0031
1.7	.8766	4.7	.4362	7.7	.1611	10.7	.0253	13.7	.0028
1.8	.8209	4.8	.4359	7.8	.1528	10.8	.0237	13.8	.0026
1.9	.7586	4.9	.4339	7.9	.1448	10.9	.0221	13.9	.0024
2.0	.6914	5.0	.4303	8.0	.1371	11.0	.0206	14.0	.0022
2.1	.6208	5.1	.4253	8.1	.1297	11.1	.0192	14.1	.0021
2.2	.5480	5.2	.4191	8.2	.1226	11.2	.0179	14.2	.0019
2.3	.4742	5.3	.4119	8.3	.1159	11.3	.0167	14.3	.0018
2.4	.4004	5.4	.4037	8.4	.1094	11.4	.0156	14.4	.0016
2.5	.3276	5.5	.3947	8.5	.1032	11.5	.0145	14.5	.0015
2.6	.2565	5.6	.3851	8.6	.0973	11.6	.0135	14.6	.0014
2.7	.1877	5.7	.3749	8.7	.0918	11.7	.0126	14.7	.0013
2.8	.1217	5.8	.3642	8.8	.0864	11.8	.0117	14.8	.0012
2.9	.0591	5.9	.3532	8.9	.0814	11.9	.0109	14.9	.0011
3.0	.0000	6.0	.3419	9.0	.0766	12.0	.0101	15.0	.0010

EPS HOUSEKEEPING SPECIFICATION

General: To insure proper operation and maintenance of the EPS hardware a total of twenty (20) parameters must be monitored using two (2) spacecraft high level, low rate analog FM channels. Since the detectors' temperature controls the spectrometer's operating mode, a wide range detector temperature sensor will be monitored on one channel singularly. The other nineteen (19) monitors and two sync channels will be multiplexed onto the second TM channel.

The total complement of monitors is:

<u>Parameter</u>	<u>Quantity</u>
+8	1
-8	1
+28	1
+5	1
-5	1
-5 (reference)	1
+350 (bias)	1
Electronic Package Temperature	1
Wide Range Detector Temperature	1
Narrow Range Detector Temp. Monitor	1
Detector Leakage Current Monitor	5
Electronic Noise Monitor	<u>5</u>
Total	20

TM Interface: Each of the analog TM channels assigned to the EPS has the following characteristics:

Input Range	0 to +5 VDC
Input Impedance	$\geq 1 \text{ M}\Omega$
Input Shunt Capacitance	$\leq 2.2 \text{ }\mu\text{f}$
Sample Rate	1.25/second
Sample Interval	$\leq 20 \text{ }\mu\text{seconds}$
Sync Availability	None
Required Source Impedance	$\leq 10 \text{ K}\Omega$

Detailed Specifications: The analog multiplexer/buffer system will have the following end to end characteristics:

TM output range	0.000 to +5.000 volts into $1 \text{ M}\Omega$
Output Impedance	$1.00 \text{ K}\Omega \pm 0.1\Omega$ orig. temp. range
Short Circuit Duration	∞
Integral Nonlinearity	$\leq 0.1\%$
Gain Stability	$\leq 0.1\%$ over the allowable package temperature
Zero Stability	$\leq 5.0 \text{ mvolts}$ over the allowable package temp.
Tolerance to induced noise in signal line	Must meet or exceed the requirements of tests CE02, CE04, RE01, RE02 and RS03 of MIL-STD 461A.
Buffer Amplifier Input Bias Current	$\leq 10 \text{ nAmps}$ over the allowable temperature range.
Power Requirement	<p>@ +8 VDC</p> <p>@ -8 VDC</p> <p>@ +5 VDC</p>
Power Supply Rejection	No loss in monitor characteristics for a $\pm 1 \text{ volt}$ variation in any supply voltage.
Operating Temperature Range	$-25^\circ\text{C} \leq T \leq +25^\circ\text{C}$
Survival Temperature Range	$-50^\circ\text{C} \leq T \leq +50^\circ\text{C}$

Design Responsibility: The housekeeping subsystem engineer will have the responsibility of designing all components of the analog system with the exception of:

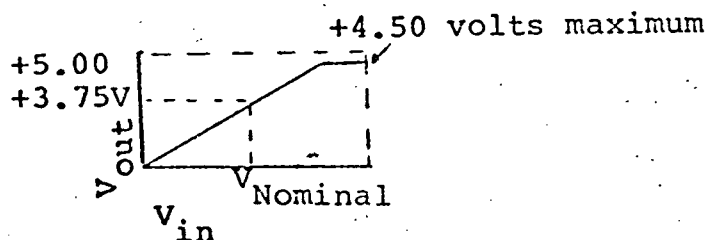
- A. The five leakage current monitors
- B. The noise monitor and its associated input multiplex circuitry.

However, in these two cases the housekeeping subsystem engineer will determine output specifications necessary to properly interface with the ensuing multiplexer.

Location: The entire housekeeping subsystem with the exception of the five leakage current monitors and the multiplexed noise monitor will be located in the Data Processor module.

Detailed Sensor Specifications

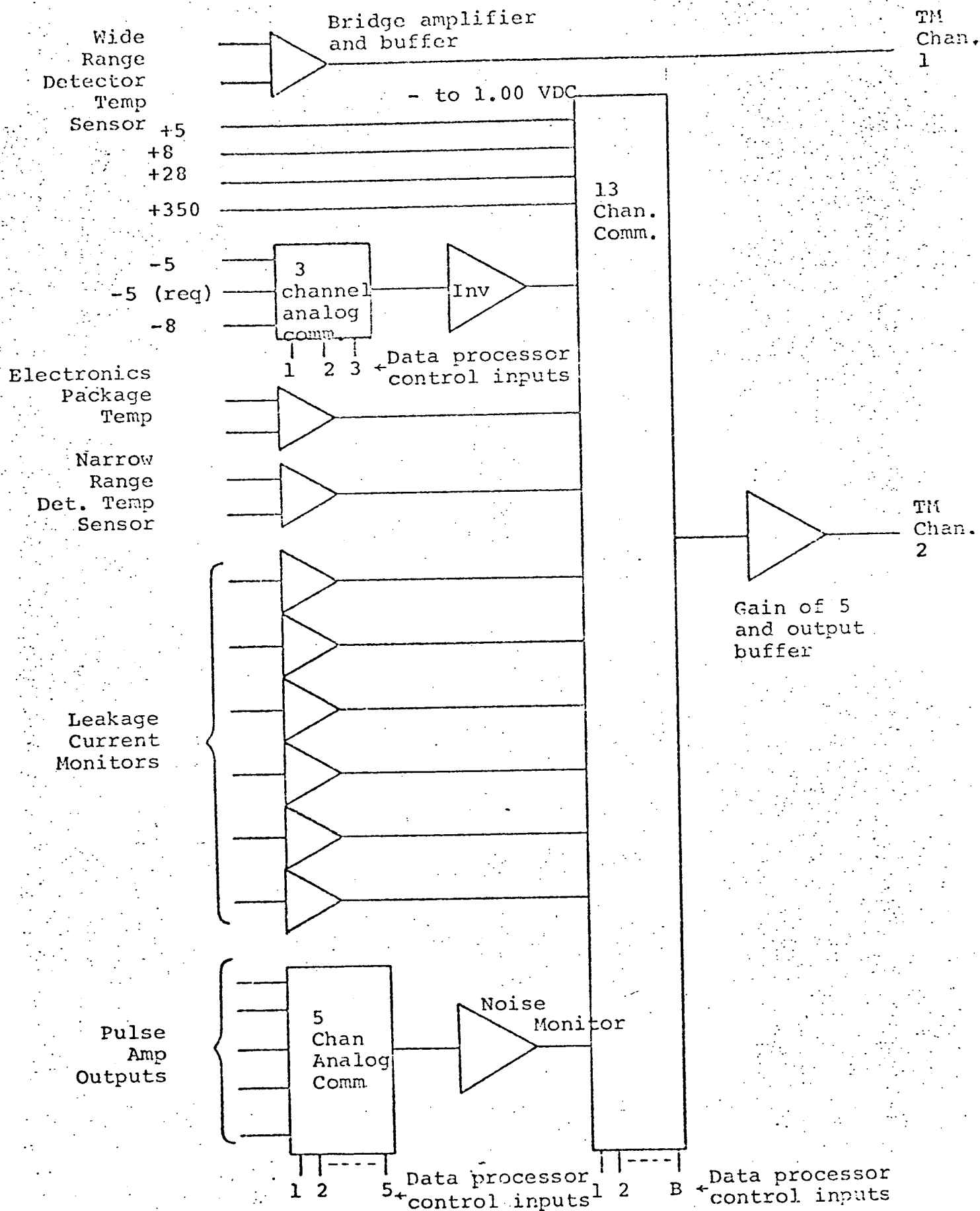
- A. Wide range detector temperature sensor
 - 1. Range -100°C to $+100^{\circ}\text{C}$
 - 2. Accuracy* $\pm 5^{\circ}\text{C}$
- B. Electronics Package Temperature Sensor
 - 1. Range -100°C to $+100^{\circ}\text{C}$
 - 2. Accuracy* $\pm 5^{\circ}\text{C}$
- C. Narrow Range Detector Temperature Sensor
 - 1. Range -25°C to $+30^{\circ}\text{C}$
 - 2. Accuracy* $\pm 0.5^{\circ}\text{C}$
- D. Leakage Current Monitors
 - 1. Range 0 amp to 5 amp
 - 2. Accuracy* ± 5 namp
- E. Resolution Monitor
 - 1. Range 0 Kev (FWHM) to 100 Kev (FWHM)
 - 2. Accuracy* ± 1 Kev (FWHM)
- F. Voltage Monitors
 - 1. Range



- 2. Accuracy $\pm 0.5\%$
- G. Positive Analog Sync
 - 1. D.C. Output* $+5.000 \pm 0.01$ volt
- H. Ground Analog Sync
 - 1. D.C. Output* 0.000 ± 0.01 volt

*Indicates accuracy over the entire environmental range.

A PROPOSED MONITOR BLOCK DIAGRAM



3.2.1.5.C Mission Interface (Times of Hardware Operation)

The determination of mission profiles are defined by the Skylab Program Office. Certain requirements of the mission total times are defined by the ICD. The ability of the EPS to meet these requirements and to operate in hostile environment for more than the required mission times is reflected by the FMEA and the Qualification Test Report. A mean-time-between-failure analysis of the original concept of an operation time of two years is met. A worse case rough analysis of the entire system estimates a mean-time-to-failure (MTTF) of 21,500 hours. This MTTF does not include the detectors.

3.3.1.7.1 Structural Factors of Safety

The original design of the EPS incorporated factors of safety as required to meet this requirement. After the higher test levels were received, there was some doubt as to whether the design had a sufficient factor of safety. A computer calculation performed very recently indicates that the EPS design continues to meet this requirement even when stressed to the higher test levels.

3.3.2.4 Electrical Connectors - Pin Assignment and Pin or Socket Selection

All electrical connectors used in the EPS were analyzed during the Single Point Failure Analysis and the Failure Mode Effects Analysis (FMEA). The requirements of paragraph 3.3.24 of MSC-KA-69-44 were met with emphasis on mishaps due to design, operational and procedural deficiencies, environmental conditions, personnel error, and normal equipment operation.

- a. All connectors in slices are keyed and cannot be mated wrong. Also connectors (slices) cannot be de-mated with power on instrument. Hence, no hazard.
- b. A statement indicating 'power must be off' during installation in spacecraft will be added to installation and handling procedures.

3.3.2.6 Material Detrimental to Electrical Connectors

Non-metallic materials used on the EPS program were surveyed by LEC R&QA for compatibility. The source of this analysis is the non-metallic manual and NASA/MSD personnel. No material used on the EPS program is considered detrimental to electrical connectors. No metallic materials report is required by the contract; therefore, this effort is not documented.

No materials are used adjacent to exposed electrical contact surfaces. The only material used on or near the connector (but not near exposed contact surfaces) is PR 1538 polyurethane conformal coating on leads and rear of connector bodies. The only fluids used in cleaning are isopropyl alcohol and freon.

3.3.2.7 Electrical and Electronic Piece Parts

A fully documented parts program is available for review. This includes procurement specifications, screening specifications, EEE Parts list, and procurement requirements. The documentation meets all the requirements of this paragraph. These documents have been reviewed by NASA/MSC Reliability and Quality Assurance with no comments. The referenced documents are available for review.

3.3.2.9 Protection of Electrical and Electronic Devices

Electrical and electronic devices used on the EPS have protection against reverse polarity. Adequate diodes have been installed for circuit protection. A protection circuit has been designed to protect the instrument from spurious voltages from the spacecraft as well as protection from feedback voltages into the spacecraft from the instrument.

3.3.4 Debris Protection

- a. Electrical circuitry - prevent unwanted current path being produced by debris

The EPS consist of an inner subassembly containing four "slices" (modular aluminum housings containing printed wiring boards and electronic subassemblies encapsulated in their own aluminum housings), which is shock-mounted within an outer mechanical housing. The top plate containing the detector assemblies is mounted onto the inner assembly leaving a gap around the upper edge of the outer housing to allow any movement due to the vibration isolators. This gap is concealed by a flexible silicone skirt to prevent open access to the inner assembly and act as a reflective shield for thermal control yet not affecting the controlled thermal conduction between the outer housing and the top plate/inner electronics assembly. Any contaminants and/or debris could penetrate the outer housing only through this gap and reflective shield. When the four slices are mated, there are covers between each printed wiring board and its mating printed wiring board. This results in an assembly which is sealed except for access holes to test point jacks in two ends of the upper three slices. Each access hole presents access to only one cavity and printed wiring board. The printed wiring boards are conformally coated with PR 1538, a polyurethane, on both sides as protection against moisture, contaminants, etc. Each printed wiring board was designed to mount in a separate cavity shielded from any other cards or electronic subassembly. All wire or contact terminations are conformally coated or encapsulated.

b. Critical mechanical items covers and containers

The eight vibration isolators are contained within the EPS outer housing in pockets with access when required through covers. The detectors are enclosed within hermetically-sealed housings for protection and selection of energy levels. The EPS is supplied with a protective glass fiber cover over the upper half of the experiment which is secured in a shipping and testing stand for protection until installation in spacecraft where a boost cover is employed. All electronic subassemblies are mounted in compartments in slice assembly configurations, which makes any subassembly inaccessible without dismantling the inner assembly.

d. Threaded fittings and fasteners

All fasteners used in the EPS are used with heli-coil screw-lock inserts to positively secure threaded members against loosening caused by vibration and shock and to protect tapped threads against wear and damage in use. All mechanical and electro-mechanical assemblies are cleaned per MSC C-8, Class A. All mechanical parts are packaged per MSC-SPEC-C-12A or MSC10M01836 Paragraph 5.1 and 5.2 (for parts with thermal control coatings) until assembly in a controlled access area or clean room. Upon final assembly all subassemblies are cleaned per MSC C-8, Class A. This cleaning prevents contaminants and/or debris in tapped holes or other limited access areas which could loosen and contaminate areas of the EPS. No self-tapping screws, bolts, or quick-acting fasteners are used. In all four slices, where tapped holes are not blind, they are open outside the hardware so that debris will not be released inside.

3.3.6.1 Test Points

During the early phase of the development of the EPS it was established that there would not be any testing of the EPS after it was installed on the spacecraft other than observing the output of the instrument thru the normal telemetry system. Therefore, all test points contained within the EPS are for laboratory use only.

3.3.6.2 Test Equipment

Development analysis of the Bench Test Equipment (BTE) was made based on the ICD and EPS requirements. The approach was to make the overall acceptance test procedures as simple as possible. The BTE simulates the spacecraft interface such that all inputs/outputs to the EPS are tested in such a way to guarantee proper minimum/maximum level signals. The BTE has been designed and proved by tests and operation.

There are three sources of power in the BTE which are used to power the various interfaces as well as the EPS itself. The computers internal 6 volt supply powers all logic used in the BTE, the ± 15 volt dual supply powers the input interface board and the 8 channel digital to analog converter, and the 25 to 30 volt supply is used exclusively to power the EPS. All power supplies have internal current limiting and over voltage protection to completely protect the EPS and the various subassemblies of the BTE from damage due to power supply malfunction.

3.3.7 Single Point Failure

The "Electron-Proton Spectrometer Single-Point Failure Report", EPS-424 is presented to satisfy this requirement.

ELECTRON-PROTON SPECTROMETER
SINGLE-POINT FAILURE REPORT

LEC Document Number EPS-424

Prepared by

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

For

National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

August 1971

SINGLE-POINT FAILURE REPORT

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SINGLE-POINT FAILURE ELECTRON-PROTON SPECTROMETER

1. PURPOSE

A single point failure summary identifies the critical areas that will, as a result of a single assembly failure, cause a complete or partial loss of the experiment, questionable data, or complete loss of data acquisition. The following information must be delineated:

- Corrective action taken
- Experiment objective and,
- Justification for retaining a single point failure

2.0 CORRECTIVE ACTION

The requirements of the Electron-Proton Spectrometer (EPS), such as weight to power limitations, logic, and electronic circuit packaging, limit redundant circuits and components. As a result, corrective action to reduce the possibility of critical failures is applied through careful selection of the best available high-reliability components, screen and burn-in tests, and derating of components used in the circuits.

3.0 JUSTIFICATION FOR RETAINING SINGLE POINT FAILURES

Space and weight are important factors in the EPS; consequently, there are no redundant logic and electronic circuits. Most of the components used have a long life expectancy. Hi-Rel micro circuits have a predicted Mean-Time-To-Failure (MTTF) rate of five to ten years.

Discrete components have been selected to the high reliability requirements of MIL-STD 883, MIL-STD 202, established reliability programs, or have been screened to Hi-Rel requirements. Component derating further increases the life span. Worst case analysis of the entire system estimates a MTTF of 21,500 hours. This is several times the hours required by mission objectives. The above MTTF does not include the detectors.

4.0 MISSION OBJECTIVE

To measure electron and proton radiation the instrument accepts charge pulses from the detectors. These pulses are shaped and amplified and trigger discriminators at different energy levels. The discriminators outputs are fed into the data processor for telemetry processing.

5.0 SINGLE-POINT FAILURE ANALYSIS

5.1 DATA PROCESSOR

5.1.1 Counter Memory

Ten channels of input information from the discriminators are processed and shifted to the Sequence Control and Digital Data Compressor. The data consists of 4 channels of electron and 6 channels of proton information. A failure of any one channel would result in 10 percent loss of data critical to the mission.

5.1.2 Sequence Control

A failure of the Sequence Control could result in no data output from the Data Processor, including housekeeping events. All common Digital Data Output, Column Sync, Word Sync, Multiplexer Address Advance, housekeeping gates, A/D Converter Start, etc., are dependent on the Sequence Control.

5.1.3 Digital Data Compressor

Failures in the Digital Data Compressor could result in no output data from the Word Sync Generator and Output Buffer, resulting in no data readout to telemetry.

5.1.4 Multiplexer A/D Analog Section

This section of the Data Processor handles housekeeping events. A failure in any part of the Multiplexer would have very little effect on the mission critical data.

5.1.5 Multiplexer A/D Converter Logic

A failure in this section would not effect mission critical data.

5.1.6 Word Sync Generator and Output Buffer

Failure in this section of the Data Processor could result in complete loss of output to telemetry.

5.1.7 Filter Module

This module contains one Output Filter for each telemetry data channel. Failure of a data point filter would result in no data out on one telemetry data channel.

5.1.8 Voltage Monitor

A failure of the Voltage Monitor would have negligible effect on the mission critical data of the EPS.

5.2 LOW VOLTAGE POWER SUPPLY

5.2.1 Preregulator

Failure of the Preregulator could result in erratic output or no output from Preregulator with a possible loss of power to the EPS.

5.2.2 Core Driver

A failure of this driver would result in erratic operation, loss of switching or possible loss of power to the EPS.

5.2.3 Transformer Assembly

A failure of the Transformer Assembly could result in possible loss of a portion of the power to the EPS or possible loss of all low voltage power.

5.2.4 Discriminator Reference Regulator

A failure of the Regulator could result in reduced power input to the Transformer Assembly, power loss to transformer, or possible loss of all low voltage functions.

5.2.5 Inductor Assemblies

Failure in an Inductor Assembly could result in erratic output or loss of one or more of the power supply outputs.

5.3 DETECTOR BIAS POWER SUPPLY

Loss of Detector Bias would result in no primary data. Detectors would not function. Secondary data (housekeeping information would still be obtained).

5.4 HEATER

5.4.1 Heater Control

Loss of the Heater Control Circuit would result in a possible temperature variation that could cause loss of or erroneous data.

5.4.2 Heater Circuit

The Heater Circuit is not normally on during EPS operation. During down or storage time the effect of failure in the Heater Circuit would depend on orbit mode. At Beta 0° no effect would be noticed. At Beta 73° the EPS survival could be effected.

5.5 NOISE MONITOR (5 each)

Failure of the Noise Monitor function would result in a loss of housekeeping events. Effect on the operational data of the EPS would be minor.

5.6 LEAKAGE CURRENT MONITOR (5 each)

Failure of the Leakage Current Monitor would cause a loss of housekeeping events. This event would have minor effects on the primary data received from the EPS.

5.7 PREAMPLIFIER (5 each)

Failure of any one Preamplifier would cause a loss of 20 percent of the primary data inputs to the Data Processor.

5.8 PULSE AMPLIFIER (5 each)

Failure of any one Pulse Amplifier would result in the loss of 20 percent of the primary data to the data processor.

5.9 PULSE HEIGHTS DISCRIMINATOR (5 each)

Failure of any one of the Pulse Height Discriminators would result in 20 percent loss of primary data to the Data Processor.

5.10 INPUT FILTER

Failure of the Input Filter would cause the loss of either all data, primary data only, or Heater Control only.

5.11 DETECTORS

If one of the Detectors failed, two channels of information would be lost (1 Electron, 1 Proton). Twenty percent of mission critical data would be lost.

5.12 CONNECTORS

5.12.1 1 PPS

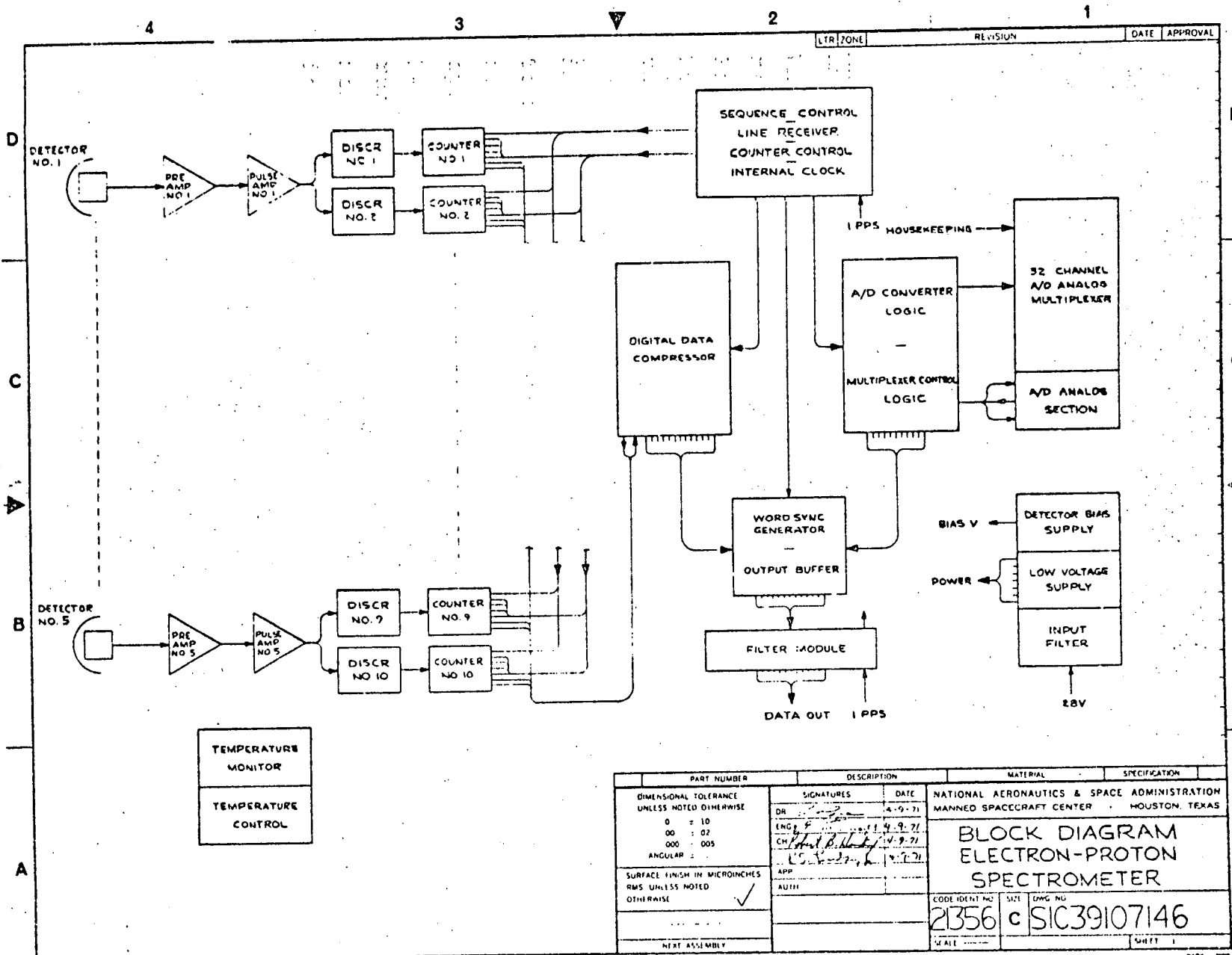
Clock Sync Pulse for cycling data and timing for data processor. Failure of 1 PPS would result in loss of all data.

5.12.2 Input, Detector Bias Supply

Failure of input to bias supply would result in loss of detector operation.

5.12.3 Input 28 Vdc To Instruments

A failure of input power would result in loss of all power to instrument.



3.3.9 Selection of Specifications and Standards:

Parts and material conforming to various Government specifications were selected in the precedence required. Certain parts required for the EPS were not available as Established Reliability Parts. Procurement of these parts was handled in three different ways, i.e.

Vendors Specifications,
Procurement Specifications, and
Screen and Burn-In.

VENDORS SPECIFICATIONS

When vendors specifications were available, they were reviewed. If the specifications complied with NASA Reliability Requirements for flight hardware, parts were procured on this basis. Specification Test Sheets are available on request on these parts.

PROCUREMENT SPECIFICATIONS

To meet the requirements for High Reliability Parts when suitable vendors specifications were not available, procurement specifications were written to ensure that vendors' testing programs would be upgraded to qualify their parts under NASA requirements for High Reliability Flight parts. The Procurement Specifications were published in EPS-239, a copy of which is attached.

SCREEN AND BURN-IN SPECIFICATIONS

Some parts did not lend themselves to these approaches and were purchased as commercial and JAN parts and subjected to a Screen and Burn-In to qualify them as Hi-Rel Parts. The Screen and Burn-In was conducted at the NASA White Sands Test Facility. These tests were designed to meet Specification for Semiconductors, MIL-S-19500; Test Requirements for Semiconductors, MIL-STD-750; Test Methods for Electronic Parts, MIL-STD-202D; and MSC Reliability Parts Program Requirements, MSC-3515. The Screen and Burn-In Specification are included as a part of EPS-239.

EPS FLIGHT UNIT
PROCUREMENT AND
RELIABILITY REQUIREMENTS

LEC Document Number EPS-239

Revision A. Added EPS-356 and page 2-9
Revised pages 2-5, 2-6, and
2-7

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EPS FLIGHT UNIT
PROCUREMENT AND
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EPS FLIGHT UNIT
PROCUREMENT AND
RELIABILITY REQUIREMENTS

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SECTION 1

EPS FLIGHT UNIT PROCUREMENT AND RELIABILITY REQUIREMENTS

INTRODUCTION

This document brings together a compilation of the reliability requirements for parts/components for use in (procured for) the Electron/Proton Spectrometer (EPS) Qualification and three flight units. The reliability data contained herein provides a visibility of parts selection and reliability requirements for the EPS to insure a parts program that will meet the extended life criteria of the EPS, and to meet the NASA/MSR reliability requirements.

A few parts, which meet the design requirements of certain aspects of the instrument, could not be obtained in the quality grade of established reliability parts. For these particular parts, which require screening and extra testing, applicable procurement and screen and burn-in specifications are included in this document.

Cognizant personnel associated with the reliability and quality assurance aspects of the EPS program are urged to bring to the attention of the LEC Reliability Engineer any errors or omissions in, or modifications of any statements or requirements contained herein so that appropriate corrective action can be made in a timely manner.

SECTION 2

EPS FLIGHT UNIT COMPONENTS RELIABILITY REQUIREMENTS

The following list provides a visibility of the parts selection and the reliability requirements required for the procurement of parts/components for the EPS.

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec./ Mil Spec	LEC Spec	Mfr. Spec	Other Specs	Gov't Source Insp.	Lot Trace-ability	C of C require
U055	Solder	44	Kester	QQ-S-571D					X	X
U153	Detectors, 20-505		SSR		EPS-125				X	X
U154	Detectors, 20-606		SSR		EPS-125				X	X
U155	Detectors, 20-707		SSR		EPS-125				X	X
U156	Detectors, 25-808		SSR		EPS-125				X	X
U157	Detectors, 25-909		SSR		EPS-125				X	X
U158	Detectors, 20-404		SSR		EPS-125				X	X
U159	Drift measurements silicon ingot, detectors for 30-404		SSR		EPS-125				X	X
U166	Connector, 20-505	ME414-0120-0021	Kierulf	Not used		MC414-365, Rev. C & PDC-1a, -2, -3A & -4		X	X	X
U167	Connector, 20-606	ME414-0120-0021	Kierulf	Not used				X	X	X
U168	Connector, 20-707	ME414-0120-0021	Kierulf	Not used				X	X	X
U175	Connector, Coax Receptacle	CX-RB-M-0	ITT Cannon Greyamar				100% visual inspection, insulation resistance, dielectric withstanding voltage tested		X	X

EPS FLIGHT UNIT COMPONENTS RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr Spec	Other Specifications	Gov't Source Insp	Lot Trace-ability	C of C require
U176	Connector, Coax Receptacle	CX-RB-M-0	ITT Cannon Greymar				100% visual inspection; insulation resistance, dielectric withstanding voltage tested		X	X
U177	Connector, Coax Receptacle	CX-RB-M-0	ITT Cannon Greymar				100% visual inspection; insulation resistance, dielectric withstanding voltage tested		X	X
U178	Connector, Coax Receptacle	CX-RB-M-0	ITT Cannon Greymar				100% visual inspection; insulation resistance, dielectric withstanding voltage tested		X	X
U179	Connector, Coax Receptacle	CX-RB-M-0	ITT Cannon Greymar				100% visual inspection; insulation resistance, dielectric withstanding voltage tested		X	X
U180	Connector	ME414-0120-0021	Kierulf Elect.	Not used		MC414-0365, Rev. C		X	X	X
U181	Connector	ME414-0120-0021	Kierulf Elect.	Not used		& PDC-1a,-2,-3A&-4		X	X	X
U218	Thermistor, 4.7K ±5% @ 25°C	RTH06BS472J	Victory Eng.	MIL-T-23648			168 hour burn-in @ 0.2W, @ 85°C: 100% elect. tests req. after burn-in: all units must meet prior est. electrical & temperature parameters		X	X
U219	Potentiometer	3260H-1-XXX	Bourns	MIL-R-27208 (RT26) MIL-R-22097 (RT27)	EPS-124				X	X

EPS FLIGHT UNIT COMPONENTS

RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr Spec	Other Specifications	Gov't Source Insp	Lot Trac-ability	C of C required
U220	Amplifier	SE526K/883	Signetics	MIL-STD883A			X-ray U-221-1 893-Level A testing		X	X
U221	Amplifier	HA2-2520-2	Harris	MIL-STD883B					X	X
	Multiplexer, 16 ch	HS9-1000-2	Harris	MIL-STD883B					X	X
U222	Inductor, 20 mh	526-2930-130	Collins	MIL-T-27B			168 hr burn-in at rated power & 125°C		X	X
U223	Transistor, PNP	2N5333	Texas Inst				Screen and Burn-in at W.S.		X	X
U224	Transistor	2N4878	Intersil				Screen and Burn-in at W.S.		X	X
U225	FET	JAN2N2609	Teledyne	MIL-S-19500					X	X
U226	Transistor	SS3520	Motorola	MIL-S-19500			$h_{fe} > 100 @ 2ma, 1kHz \& 15V;$ $h_{FE} = \min 25; f_T > 500mHz @ 1mA \& 15V$ Screen and Burn at W.S.		X	X
U226	Transistor	JAN2N3811	Motorola	MIL-19500			$h_{fe} > 100 @ 2ma, 1kHz \& 15V;$ $h_{FE} = \min 25; f_T > 500mHz @ 1mA \& 15V$ Screen and Burn at W.S.		X	X
U231	Capacitor, Variable 0.8-2.5 pf	RVC-12	JFD		EPS-232				X	X
U232	Transistor	JANTX2N	Texas Inst	MIL-S-19500					X	X
U232	Diode	JANTX1N	Texas Inst	MIL-S-19500					X	X

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr. Spec	Other Specifications	Gov't Source Insp.	Lot Trace-ability	C of C required
U233	Diode, 1N4567A	1N4567A 1N4901A	Dickson	MIL-S-19500/159, 127			To satisfy TX requirements		X	X
U234	Diode	JANTX1N 4942, UT4010	Unitrode	MIL-S-19500			To satisfy TX requirements		X	X
U235	Amplifier	LM108/883 uA723/883	Adv. Micro	MIL-Std883B					X	X
U236	Inductor, 100phy	PD-100	Nytronics		EPS-167		ORDER CANCELLED.		X	X
U237	Filter	8332-125, 126, 201	Potter	MIL-F-15733		8000	Environmental & burn-in (Potter spec dated 1970)		X	X
U246	Capacitor	828-1KV- X5T-103M	Erie	MIL-C-11015D	EPS-121		Cap - offset leads - anti-corona undercoating - not to be dipped in wax, 100% visual. Corona start voltage to be measured.		X	X
U247	Diode	5082-2123	Hewlett Packard	MIL-S-19500, MIL-STD 750			To be tested to Hewlett Packard's specification sheet for Hi-Rel application		X	X
U248	Connector	MCDM1	Microdot	MIL-C-24308, MIL-C-83848					X	X
U249	Magnetic Cores	52002-1A 52134-1A 55037-W4 55040-W4 55051-W4 55121-W4 80530-1A	Magnetics, Inc.	NASA QA Acceptance					X	X

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr. Spec	Other Specifications	Gov't Source Insp.	Lot Trace-ability	C of C required
U250	Magnet Wire	80XX	Belden						X	X
U251	Resistor, Film	MK132	Caddock	MIL-R-55182	EPS-116		Reliability and QA Data required.		X	X
U252	Resistor, Carbon	RCR07, RCR20	Allen-Bradley	MIL-R-39008			Established Reliability		X	X
U253	Capacitor	CKR05, CKR06	Kemet	MIL-C-39014			Established Reliability		X	X
U254	Integrated Circuits (TTL)	SNC54, SNH54	Texas Inst	MIL-STD 883, Level A					X	X
U257	Connector	NBH16-26PH	Deutsch	NASA 40M 39569			Hermetic seal jam nut mounting, environmental resisting 200°C		X	X
U261	Resistor	1712-100 meg	Caddock	MIL-R-55182	EPS-168		Reliability and QA Data required.			
U262	Transistor	SS3515	Motorola	MIL-S-19500			Selected from JANTX2N 3251A. hfe=150 min @ Ic=1mA: VCE=10V & f=1KHz; FT=35-mHz min @ Ic=-3mA: VCE=10V & f=100 mHz: Cob=5pfmax @ Vcb=8V; Ig=0mA and f=100kHz.		X	X
U262	Transistor	SS2638H	Motorola	MIL-S-19500, MIL-STD 883, Level A			Selected from MM4261H: BVCEO=20Vmin @ Ic+10mA hfe=55 min & 150 max @ Ic=4mA DC and VCE=5V Ccb=2 pf max VCB=1VDC		X	X

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr. Spec	Other Specifications	Gov't Source Insp.	Lot Trace-ability	C of C required
U263	Resistor	RNC50, RNC55	Mepco	MIL-R-55182C			Established Reliability, F tolerance, R or S failure rate		X	X
U264	Capacitor	RC33, RC12, RC37	USCC	MIL-C-39014			Temp. Cycling, 100 hr burn-in @ 200% rated power, DR, IR, Dissipation factor		X	X
U269	Transistor	JANTX2N2484	Teledyne	MIL-S-19500/376					X	X
U270	Voltage Comparator	LM111/883	Advance Micro	MIL-STD 883, Not.B			MIL-STD 883 level A & X-ray		X	X
U271	Switch	DAS2132	Dickson	MIL-STD 883, Not 2 Met. 5004					X	X
U279	Connector (Coax)	031-0070 -001	Microdot				Insulation Resistance, Dielectric Withstanding Voltage, Contact Resistance and Vibration to be performed 100%.		X	X
U281	Capacitor, Polycarbonate	X483W4	TRW	MIL-C-18312, MIL-C-19978B			Hi-Rel testing - temperature & imersion cycling, 240 hour burn-in @ 125°C		X	X
U287	Sensistor	TG51	Texas Inst	MIL-T-23648			Temp Cycling, Leak Test & 48 hour burn-in @ 150°C		X	X
U290	Thermal heater Dissipator	TXP0508ND TX0561ND	Int'l Elec Int's Elec				Temp Cycling, 168 hr burn-in		X X	X X

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR #	Description	Mfr. Number	Source	Federal Spec/ MIL Spec	LEC Spec	Mfr. Spec	Other Specifications	Gov't Source Insp.	Lot Trace-ability	C of C required
U303	Transistor	SSC6113	Texas Inst	MIL-S-19500/1385			Selected from JAN TX 2N4858. Gm(min)=18000 micro-mhos: VGS Range =.3V to .6V @ IDS=10mA & VDS=4V.		X	X
U318	Capacitor	T210	Kemet	MIL-C-39003			Established Reliability		X	X
U324	Inductor	MS90538-12	J.W. Miller Co.	MIL-C-15305			Temp. Cycling & 168 hr burn-in at rated power.		X	X
U320	Chromel A Wire	242-594 424-610	Curtin Scien. Co.	Not used					X	X
U327	Socket	332223	Amp Inc						X	X
U332	BEO Mounting Disc	D-350-19	Thermalloy						X	X
U333	Resistor	RWR-81S R500-FR RWR-81S 1R-300FR	Dale	MIL-R-39007B			R failure rate		X	X
U337	Gold Dumet Leads								X	X
U356	Resistors	RCR05	Allen-Bradley	MIL-R-39008			Established Reliability		X	X
U357	Resistor	RNC50,RNC55	Mepco	MIL-R-55182C			R or S Failure Rate		X	X
U358	Capacitor	RC10C	USCC	MIL-C-39014			Temp Cycling, 168 hour burn-in, dissipation factor, insulation resistance, dielectric withstanding voltage.		X	X

EPS FLIGHT UNIT COMPONENTS
RELIABILITY REQUIREMENTS

PR No.	Description	Mfr. Number	Source	Federal Spec./ Mil Spec	LEC Spec	Mfr. Spec	Other Specification	Gov't Source Insp.	Lot Trace-ability	C of C Required
U429	Carbon Resistor	RCR07G130JP	Allen Bradley	MIL-R-39008			Established Reliability		X	X
U375	Capacitor	CKR05BX	Kemet	MIL-C-39014			Established Reliability		X	X
U510	Capacitor	T210D	Kemet	MIL-C-39003			Established Reliability		X	X
U497		RC33	USCC	MIL-C-39014			High Rel. Testing		X	X
U450	Transistor	JAN2N3811	Motorola	MIL-S-19500	EPS-129		Screen & Burn-in White Sands Test Facility Replacement for failed parts on screen & burn-in		X	X
U462	Transistor	2N4848	Intersil		EPS-175		High Reliability pre seal inspect tested to - EPS-175 (screen and burn-in) - Replacement of commercial version		X	X
U372	Integrated Circuit	U4L96L 051/883	Advance Micro	MIL-STD-883/Level A			High Reliability Tested		X	X
U480	Inductor	8336-001	Potter	MIL-C-15305			High Reliability Tested		X	X
U511	Inductor	8336-001	Potter	MIL-C-15303			High Reliability Tested		X	X

PROCUREMENT SPECIFICATION
FOR
LITHIUM-DRIFTED SILICON DETECTORS

Document Number EPS-819

7-26-72

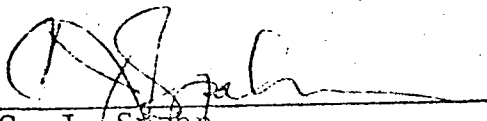
Prepared by
Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

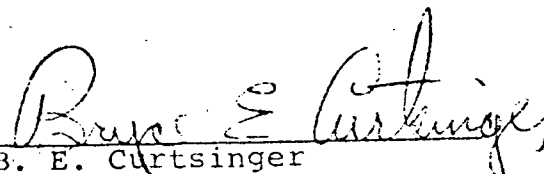
For
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

PROCUREMENT SPECIFICATION
FOR
LITHIUM-DRIFTED SILICON DETECTORS

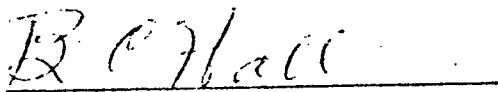
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Program Manager

Electron-Program Spectrometer Program

Lockheed Electronics Company, Inc.
Houston Aerospace Systems Division

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1.0 SCOPE

This document defines the electrical, mechanical and environmental specifications and initial acceptance tests for the procurement of lithium-drifted silicon detectors for use on the Electron-Proton Spectrometer (EPS) being developed by Lockheed Electronics Company for NASA/MSC under Contract NAS 9-11373.

2.0 APPLICABLE DOCUMENTS

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

MSCM 8080, Manned Spacecraft Criteria and Standards

3.0 COMPONENT SPECIFICATIONS

3.1 Mechanical

3.1.1 General

The detector elements shall be cubical in shape. They shall be manufactured of lithium-drifted silicon.

3.1.2 Physical Mounting

The silicon cube shall be bonded to an aluminum oxide substrate which in turn is bonded to a TO-5 transistor header as shown in Figures 1 and 2. The header shall be supplied with a steel can (unsealed)

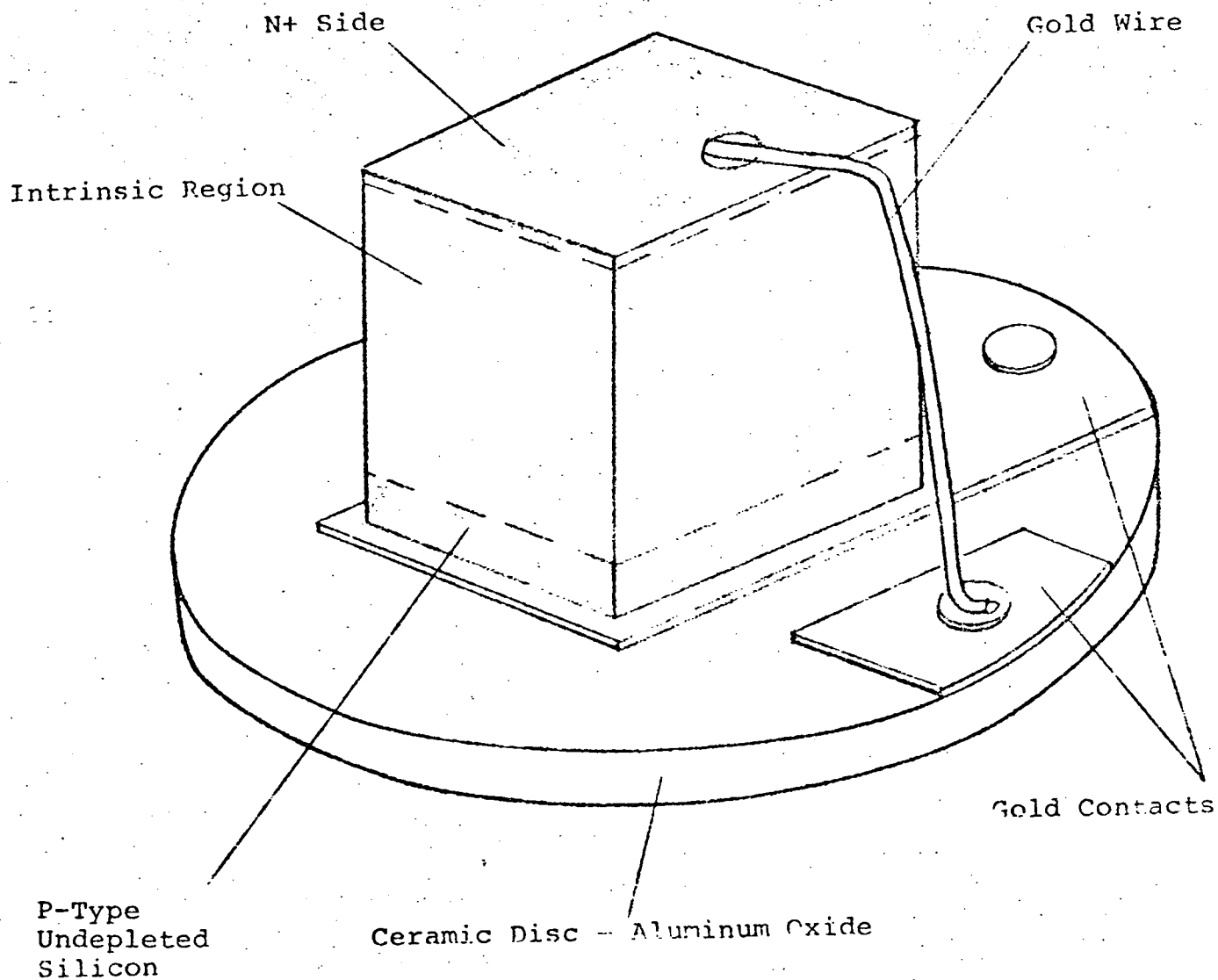


Fig. 1. View of Detector Mounting

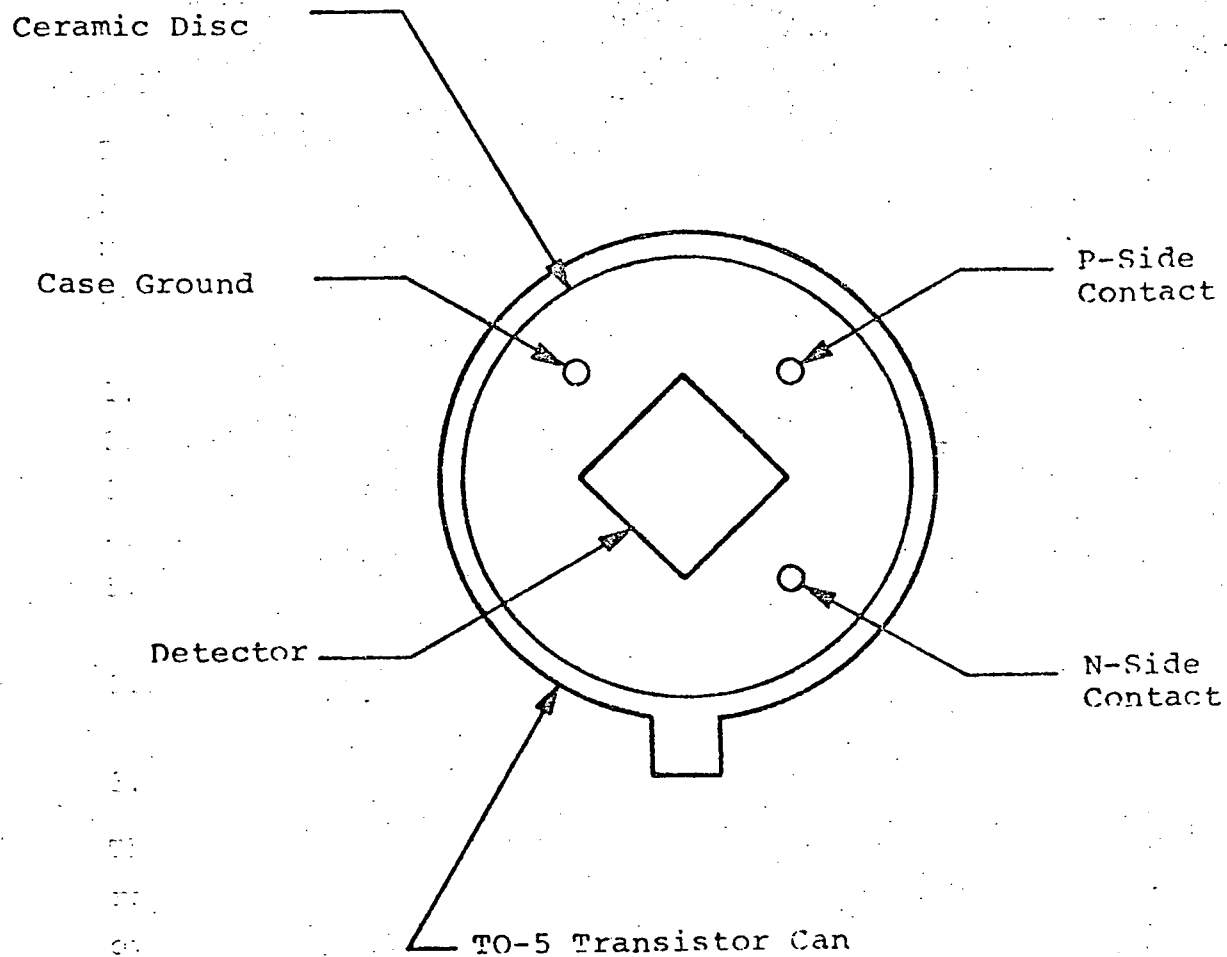


Fig. 2. Top View of Detector Mounting

3.1.3 Dimensions and Dead Layers

The dimensions of the silicon cube shall be as shown in figure

3. The five exposed sides of the detectors shall have dead layers of .0050 cm or less equivalent of silicon. The p+ (unexposed) side shall have a dead layer of nominal thickness .05 cm.

3.1.4 Identification

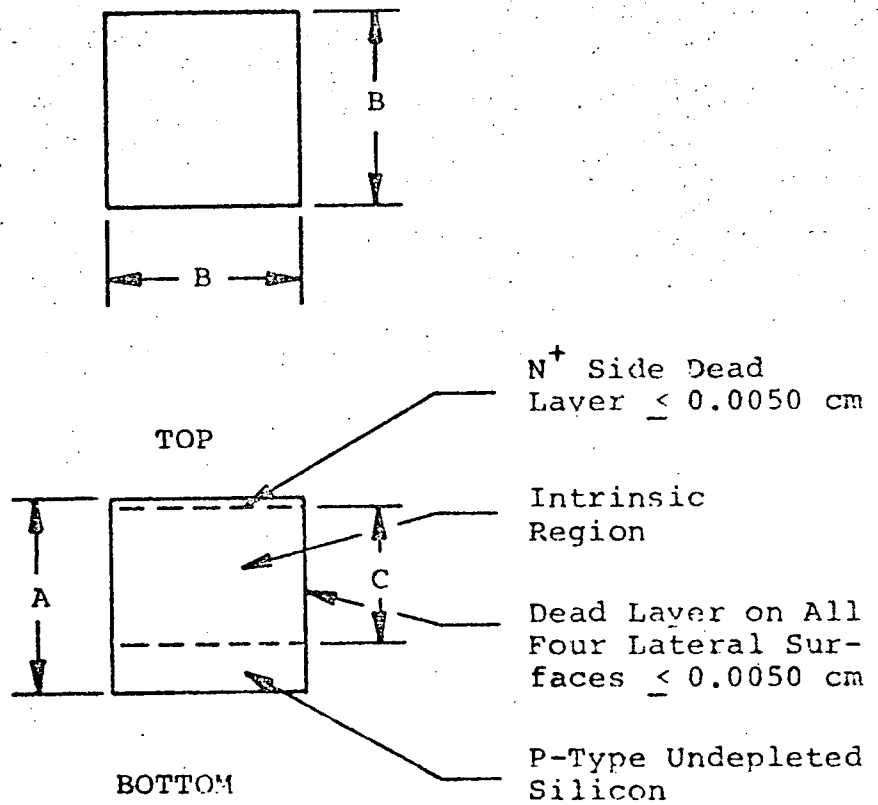
Each detector shall have a four-digit identification number painted or inscribed on its base. If painted, the paint must be vacuum compatible. The most significant digit shall be "2". Each number shall be unique and referenced to:

1. The silicon ingot used in fabrication
2. The date of detector fabrication
3. The lot number
4. The dates of testing
5. The data supplied with each detector

3.2 Environmental

3.2.1 Temperature

The detectors shall operate within specifications over the range -50°C to $+25^{\circ}\text{C}$. They shall be capable of being cycled over the range -50°C to $+60^{\circ}\text{C}$ at $1^{\circ}\text{C}/\text{minute}$. No permanent deterioration of the detector shall be incurred by exposure to a 60°C environment for a period of 24 hours providing bias is not applied during this period.



Symbol	Dimensions
A	0.255 ± 0.0050 cm
B*	0.200 ± 0.0025 cm
C	0.210 ± 0.010 cm

*Not Counting Dead Layers on Lateral Surfaces

Fig. 3. Schematic Drawing of Lithium-Drifted Silicon Detector

3.2.2 Pressure

The detectors shall operate within specifications in a dry environment of either air or nitrogen from 1000mm Hg to 350mm Hg and also over the range from 20×10^{-3} torr to less than 10^{-5} torr.

3.2.3 Vibration

The detectors shall be capable of withstanding the following vibration criteria without suffering any physical damage or degradation:

RANDOM VIBRATION CRITERIA

20 - 175 Hz @ +6 dB/Octave

175 - 350 Hz @ $6.0 \text{ g}^2/\text{Hz}$

350 - 2000 Hz @ -3 dB/Octave

$\approx 85.99 \text{ g r.m.s.}$

3.3 Electrical and Nuclear

3.3.1 Extended Bias

The detectors shall be capable of operation at an extended bias voltage of 500 volts dc over the warranty period without suffering electrical damage.

3.3.2 Leakage Current

The detectors shall have a leakage current not to exceed 2.5 microamperes at 350 volts bias at $25^\circ\text{C} \pm 1^\circ\text{C}$, and 4.0 microamperes at 500 volts bias at $25^\circ\text{C} \pm 1^\circ\text{C}$. The temperature coefficient of the leakage current shall be such that the current increases by no more than a factor of two (2) for each 8°C temperature rise above 25°C . The leakage current shall increase by not more than 25 percent per month of the value measured on the first acceptance test, referred to $25^\circ\text{C} \pm 1^\circ\text{C}$.

3.3.3 Noise

The detectors shall have a FWHM noise of ≤ 30 keV* at a bias of 350 volts at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$, utilizing a shaping amplifier with double differentiation and double integration time constants of 0.36 microseconds.** The temperature coefficient of the noise shall be such that it increases by no more than a factor of 1.41 for each 8°C rise above 25°C .

The detectors shall be free of "contact" and "microplasma" noise and shall exhibit a count rate of $< .05 \frac{\text{ct}}{\text{sec}}$ above a 200 keV discriminator level due either to noise of any kind or radioactive contamination, all at temperatures from -50°C to 25°C , utilizing a shaping amplifier with double differentiation and double integration time constants of 0.36 microseconds.

Furthermore the noise of the detector shall increase by no more than 15 percent per month of the value measured on the first acceptance test, referred to $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$.

3.3.4 Electron Resolution and Spectral Characteristics

The detectors shall exhibit a FWHM resolution of ≤ 45 keV* for the 972 keV conversion electron line of Bi-207 when the electrons impinge on the entire lithium face (uncollimated) of the detector.

* Including electronic noise

** See 3.3.7

3.3.4 Continued

The ratio of the number of counts in the peak channel of the 972 keV line to the number of counts in the peak channel of the 482 keV line of the Bi-207 spectrum shall be ≥ 1.3 (with background not subtracted). These tests are to be carried out at 350 volts bias, $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$, with double differentiation, and double integration shaping amplifier time constants of 0.36 microseconds.**

During these tests a pulser shall be fed into the test input of the preamplifier and a pulser peak accumulated with the electron spectrum.

3.3.5 Bias Tabulation

Data shall be tabulated on the total time that bias was applied to the detectors, including the temperature and the bias voltage. The time shall be tabulated to within ± 15 percent, and the temperature to within $\pm 2^{\circ}\text{C}$.

3.3.6 Calibration

The electronic system used for the tests of 3.3.3 and 3.3.4 shall be calibrated using a high quality detector of known characteristics. Namely:

1. Entrance window ≤ 1 micron equivalent of silicon.
2. Active area $\geq 50 \text{ mm}^2$.

** See 3.3.7

3.3.6 Continued

3. Depletion depth ≤ 2 mm.

4. Electron resolution:

≤ 23 keV for 972 keV Bismuth-207 electrons

All measurements shall be performed using a preamplifier with a noise of $\leq (7 \text{ keV} + 0.1 \frac{\text{keV}}{\text{pf}})$ and a shaping amplifier with double differentiation and double integration time constants of 0.36 microseconds** with the calibration detector biased for full charge collection.

During these tests a pulser shall be fed into the test input of the preamplifier and a pulser peak accumulated with the electron spectrum.

3.3.7 Shaping Time Constants

Although the detector parameters must be warranted with the specified shaping time constants, the vendor may, at his option, measure the pertinent parameters with double differentiation, single integration time constants of 0.4 microseconds.

3.3.8 Silicon Reserves

The remnants of the silicon ingot(s) from which the detectors are fabricated shall be reserved for LEC for possible future fabrication of EPS detectors for a period of 24 months from the beginning of the contract.

** See 3.3.7

3.3.9 Lithium Drift Rate

The lithium drift rate in the silicon ingot(s) used for the EPS detectors shall be measured and specified at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The accuracy of the measurement shall be within ± 25 percent.

4.0 ACCEPTANCE TESTS

4.1 Initial Acceptance Tests (performed by Vendor)

The detector shall undergo the following initial acceptance tests performed by the vendor at the place of manufacture. Lockheed Electronics Company reserves the right to have its engineers present at any or all of these tests.

4.1.1 Thermal Cycle

The detectors shall undergo one thermal cycle, from 25°C to -50°C to 60°C to 25°C , with the temperature remaining at the extremes for one hour.

4.1.2 Detector Biasing

After the thermal cycle the detectors shall be biased for at least two weeks at 350 volts at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

4.1.3 Leakage and Noise

During the biasing period, leakage, noise, and detector temperature shall be measured and recorded for each detector every seventy-two hours ± 2 hours.

4.1.4 Electron Response

At the end of the two weeks biasing period, leakage current, noise, and response to a Bismuth-207 source shall be measured and recorded.

4.1.5 Stability

If, at the end of the two week biasing period, the leakage current and/or noise of a particular detector have increased by more than 20 percent (referred to 25°C) above their initial values as measured within 24 hours after the beginning of the two week period, that detector shall be rejected although it might still satisfy the requirements of 3.3.2 and 3.3.3.

4.2 Final Acceptance Tests

Final acceptance of the detectors will occur approximately six weeks after their delivery to Lockheed Electronics Company and will be based upon tests performed by Lockheed engineers.

5.0 RELIABILITY AND QUALITY ASSURANCE PROVISIONS

5.1 Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with each detector shipment. The certificate shall verify that the detectors were processed in accordance with this specification and that all requirements have been met.

5.2 Traceability

The contractor shall assure that traceability required by Standard No. 86 in MSCM 8080 can be provided for all parts delivered. All traceability identification to the parts manufacturer's production, assembly, or test lot shall be made available in a timely manner on request from LEC and/or NASA/MS. This traceability requirement is a one way, backward traceability by part or lot code.

5.3 Record Retention

All records assembled as a result of this specification shall be retained by the manufacturer for at least two years following completion of the order.

5.4 Test Data

Test data encompassing the items of paragraphs 3.1.4, 3.3.2 through 3.3.6, and 3.3.9 shall be supplied with each detector. The data of 3.3.4 and 3.3.6 shall include plots of the spectra involved.

5.5 Preparation for Delivery

5.5.1 Unit Preparation and Packaging

Each unit procured to this specification shall be clean, dry, and packaged individually. The manner of packaging will afford adequate protection against corrosion, deterioration, and physical damage during shipment from supply source to the first receiving activity.

5.5.2 Packing

The packaged units shall be packed in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. This pack shall conform to the applicable carrier rules and regulations.

5.5.3 Marking

Each shipping container will be marked with the supplier's name and the part number.

5.5.4 Delivery

Unless otherwise specified, the supplier shall use his own delivery facilities if delivery is local, and air express if the distance is greater than 100 miles.

6.0 WARRANTY

The manufacturer shall guarantee the operation of the detectors to the specification herein, when subjected to any combination of the conditions specified herein, for a period of one year.

SECTION 4

PROCUREMENT SPECIFICATION
FOR
BOURNS POTENTIOMETER
3260 (RT26) and 3262 (RJ26)

Document Number EPS-124

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

PROCUREMENT SPECIFICATION
FOR
BOURNS POTENTIOMETER RJ 26 AND RT 26

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Electron-Proton Spectrometer Program
Advanced Programs Department
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1.0 SCOPE

This document defines the detailed high reliability requirements for Bourns potentiometer models 3260 (RT26) and 3262 (RJ26) for use on the Electron-Proton Spectrometer (EPS). Various resistance values and lead configurations will be used and are covered by this specification.

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified.

MIL-R-27208, Variable Resistor General Specifications

MIL-R-22097, Variable Resistor, Non-Wire Wound

MSCM-8080, Manned Spacecraft Criteria and Standards

MIL-STD 202D, Test Methods for Electrical and Electronic Parts

3.0 RELIABILITY AND QUALITY ASSURANCE REQUIREMENTS

3.1 Certificate of Compliance

A certificate of compliance signed by the Quality Control Manager shall be included with the device(s)

3.1 (continued)

shipment. It shall verify that the potentiometers were processed in accordance with this specification, and that all requirements have been met.

3.2 Retention of Records

The part supplier shall maintain and preserve records of evidence of compliance for a period of one year from the date of acceptance of the item by LEC. The supplier shall make his records available upon request from LEC or NASA/MSC.

3.3 Traceability

The vendor shall assure that traceability required by Standard No. 86 in MSCM 8080 can be provided. Identification to the part production, assembly and test lot shall be recorded. All traceability information shall be supplied on request of LEC or NASA/MSC. This traceability requirement is for a one-way, backward traceability by part or lot code.

3.4 Preparation for Delivery

The potentiometers shall be packed in a suitable container which will protect the body and leads of the device during shipment.

4.0 TESTS AND INSPECTIONS

All components procured to this specification shall be subjected to the following tests on a 100% basis and in the sequence specified.

4.1 Resistance Measurement

Each potentiometer shall be tested in accordance with MIL-STD-202D, Method 303. The following details shall apply.

4.1.1 Test Voltage

Measurement of resistance shall be made by using the test voltage in Table 1. This same voltage shall be used whenever a subsequent resistance measurement is made.

TABLE 1

Total Resistance, Nominal Ohms	Maximum Test Voltage Volts
10 to 100	1.0
100 to 1,000	3.0
1,000 to 10,000	10.0
10,000 to 0.1 megohm	30.0

4.1.2 Total Resistance

Total resistance shall be measured between the resistance-end elements, with the contact arm positioned against a stop. The positioning of the contact arm and terminal shall be the same for all subsequent measurements of the total resistance. The total resistance shall not deviate from the specified nominal by more than $\pm 1\%$.

4.2 Temperature Cycling

Each potentiometer shall be tested in accordance with Method 102A, Condition C, MIL-STD 202D.

Resistance measurements shall be made at the conclusion of the final cycle. The resistance measurement shall be within $\pm 1\%$ of specified values.

4.3 Vibration

Each potentiometer shall be tested in accordance with Method 204, MIL-STD 202D. The following details shall apply.

- a. Test leads - Test leads used during this test shall be no larger than AWG 22 stranded wire, so that the influence of the test leads on the potentiometer shall be held to a minimum.

4.3 (continued)

- b. Measurements before vibration - Total resistance and setting stability shall be measured as specified in 4.6.2.1 and 4.6.9.1 respectively, MIL-R-27208C.
- c. Test condition D
- d. Measurements during vibration - Each potentiometer shall be monitored to determine electrical discontinuity of the resistance element, and between the contact arm and element, by a method that shall at least be sensitive enough to monitor or register, automatically, any electrical discontinuity of 0.1 millisecond or greater duration.
- e. Measurements after vibration - Setting stability and total resistance shall be measured as specified in 4.6.9.1 and 4.6.2.1 respectively of MIL-R-27208C.
- f. Examination after vibration - Potentiometers shall be examined for evidence of mechanical damage.

4.3.1 Vibration Test Requirements

When potentiometers are tested as specified, there shall be no electrical discontinuity, and potentiometers shall meet the following requirements.

4.3.1 (continued)

Setting stability - Change shall not exceed $\pm 1\%$.

Total Resistance - Change shall not exceed $\pm 1\%$.

Operating Torque - Shall not exceed 150% of specified operating torque.

Visual Examination - There shall be no evidence of mechanical damage.

4.4 High Temperature Burn-In

4.4.1 Total Resistance and Setting Stability

Total resistance and setting stability shall be measured as specified in 4.6.2.1 and 4.6.9.1 respectively of MIL-R-27208C. The potentiometers shall then be exposed to an ambient temperature of $150^{\circ}\text{C} \pm 5^{\circ}\text{C}$ with power off, for a period of 168 hours. Not less than 2 hours after the end of the exposure time, the total resistance and setting stability shall be measured. Torque shall be measured as specified in 4.6.8.1 of MIL-R-27208C. Dielectric withstanding voltage and insulation resistance shall be measured as specified in 4.6.6.1 and 4.6.7 respectively of MIL-R-27208C.

4.4.2 Burn-In Test Requirements

When tested as specified, potentiometers shall meet the following requirements:

4.4.2 (continued)

- a. Setting Stability - Change shall not exceed $\pm 1\%$.
- b. Total Resistance - Change shall not exceed $\pm 1\%$.
- c. Operating Torque - Shall not exceed 150% of specified torque.
- d. Dielectric Withstanding Voltage - There shall be no evidence of damage, arcing, or breakdown. The leakage current shall not exceed 1 milliamperere.
- e. Insulation Resistance - Shall not be less than 1,000 megohms.
- f. Visual Examination - There shall be no evidence of mechanical damage.

TABLE 1

ELECTRICAL AND
ENVIRONMENTAL TESTS

	Paragraph
Electrical	
Total Resistance	4.1
Environmental	
Temperature Cycle	4.2
Vibration	4.3
Burn-In	4.4.2

SECTION 5

PROCUREMENT SPECIFICATION
FOR
ERIE CAPACITOR TYPE
838-1KV-X5T-103M

Document Number EPS-121

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

PROCUREMENT SPECIFICATION

FOR

ERIE CAPACITOR TYPE

828-1KV-X5T-103M

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1.0 SCOPE

This specification defines the high reliability requirements of capacitors for the Electron-Proton Spectrometer. The components shall be subjected to the specified tests in the order given.

2.0 APPLICABLE DOCUMENTS

MIL-STD-202D, Test Methods for Electronic and Electrical Parts

MSCM 8080, Manned Spacecraft Center Criteria and Standards

3.0 QUALITY ASSURANCE

3.1 Certificate of Compliance

A certificate of compliance signed by the quality control manager shall be included with all units shipped. It shall verify that the units were manufactured in accordance with this specification and that all requirements have been met.

3.2 Traceability

The Manufacturer will assure that traceability required by Std. 86 in MSCM 8080 can be provided. In addition, provisions will be made to record information relating to the specific tests performed and

3.2 (continued)

processes on each lot of parts. All traceability information will be supplied to LEC and/or NASA/MSD upon request.

3.3

Record Retention

The part supplier shall maintain and preserve records of evidence of compliance and traceability for a period of one year from date of acceptance by LEC. The supplier shall make his records available upon request.

4.0

PREPARATION FOR DELIVERY

4.1

Unit Preparation and Packaging

Each unit procured to this specification shall be clean, dry and packaged individually. The manner of packaging will afford adequate protection against corrosion, deterioration and physical damage during shipment from supply source to the first receiving activity.

4.2

Packing

The packaged units shall be packed in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. This pack shall conform to the applicable carrier rules and regulations.

4.3 Marking

Each shipping container will be marked with the supplier's name and the part number.

4.4 Shipping Method

Unless otherwise specified, the supplier shall use his own delivery facilities if delivery is local, and air express if the distance is greater than 100 miles.

5.0 ELECTRICAL AND ENVIRONMENTAL TESTS

5.1 Capacitance

Capacitors shall be tested in accordance with Method 302 of MIL-STD 202D. The following details shall apply.

- a. Test frequency 1 MHz \pm 100 kHz.
- b. Limit of accuracy \pm 10%.

5.2 Dissipation Factor

The dissipation factor of capacitors shall be measured with a capacitance bridge or other suitable method at the frequency and temperature specified. The inherent accuracy of the measurement shall be \pm 2% of the reading plus 0.1% dissipation factor unless otherwise specified. Suitable measurement techniques shall be used to minimize errors due to connections between the measuring apparatus and the specimen. The AC voltage actually

5.2 (continued)

impressed across the specimen shall be as low as practicable. When a DC polarizing voltage is required, it shall be as specified and shall exceed the peak AC voltage impressed across the specimen; however the sum of the peak AC and the DC voltages shall not exceed the voltage rating of the specimen.

The following details shall apply.

- a. Test frequencies 60 cps, 120 cps, 1 KC, 100 KC and 1 megacycle.
- b. Test temperature 25°C.

The dissipation factor shall be not greater than the percent indicated in the applicable specification sheet.

5.3 Temperature Cycling

Capacitors shall be tested in accordance with Method 102 of MIL-STD 202D. The following details shall apply.

- a. Conditioning prior to first cycle - 15 minutes at standard temperature.

5.4 Burn-In

Capacitors shall be tested in accordance with Method 108A of MIL-STD 202D. The following details shall apply:

- a. Test temperature - $85^{\circ}\text{C} \pm 3^{\circ}\text{C}$
- b. Length of test - minimum of 168, +16, -0 hours.

5.4.1 Operating Conditions

Capacitors tested shall be subjected to the dc rated voltage. The surge current shall be not less than 30 ma nor more than 50 ma.

5.4.2 Measurements During and After Exposure

At the conclusion of this test and while the capacitors are at the applicable test temperature, the insulation resistance shall be measured in accordance with Method 302, MIL-STD 202D, Condition C. The insulation resistance shall not be less than 10,000 megohms. The specimens shall be returned to 25°C and Paragraph 5.1 and 5.2 shall be repeated.

5.4.3 Corona Start Voltage

The capacitors shall be tested in accordance with Method 105C, MIL-STD 202D. The following details shall apply.

- a. Corona start voltage measured and recorded.
- b. Minimum acceptable value of corona start voltage for any unit is 1000 volts RMS.

SECTION 6

PROCUREMENT SPECIFICATION
FOR
CADDOCK RESISTORS
TYPE MK, MG AND MS

Document Number EPS-116
January 28, 1971

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

PROCUREMENT SPECIFICATION
FOR
CADDOCK RESISTORS
TYPE MK, MG AND MS

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6.0	FINAL SCREEN	6-7

1.0

SCOPE

This specification defines the high reliability requirements of resistors for the Electron-Proton Spectrometer. The components shall be subjected to the specified tests in the order given.

2.0

APPLICABLE DOCUMENTS

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

MIL-R-10509-F, Resistor Fixed Film, General Specification For

MSCM 8080, Manned Spacecraft Center Standards and Criteria

3.0

QUALITY ASSURANCE REQUIREMENTS

3.1

Certificate of Compliance

A certificate of compliance signed by the Quality Control Manager shall be included with the device(s) shipment. It shall verify that the resistors were processed in accordance with this specification, and that all requirements have been met.

3.2

Retention of Records

The part supplier shall maintain and preserve records of evidence of compliance for a period of one year

3.2 (continued)

from the date of acceptance of the item by LEC. The supplier shall make his records available upon request from LEC or NASA/MSC.

3.3 Traceability

The vendor shall assure that traceability required by Standard No. 86 in MSCM 8080 can be provided. Identification to the part production, assembly, and test lot shall be recorded. All traceability information shall be supplied on request of LEC or NASA/MSC. This traceability requirement is for a one-way, backward traceability by part or lot code.

3.4 Preparation for Delivery

The resistors shall be packed in a suitable container which will protect the body and leads of the device during shipment.

4.0 ELECTRICAL TESTS

4.1 Electrical Parameters

Measure the following parameters and record the results on an appropriate data sheet beside the applicable serial number. Reject devices exceeding the limits shown.

4.1 (continued)

- a. R (resistance) per method 302 of MIL-STD-202D.
Limit = $\pm 1\%$ of designated value.
- b. IR (insulation resistance) per method 302 of
MIL-STD 202D. VR = 200 V, limit = 1000 megohm
minimum.

4.2 Resistance Value by Type

<u>Type</u>	<u>R in ohms</u>	<u>Tolerance</u>
MK 132	800 K	$\pm 1\%$
MK 650	50 K	$\pm 1\%$
MG 660	10 M	$\pm 1\%$
MG 650	100 K	$\pm 1\%$
MG 650	4.99 M	$\pm 1\%$
MG 650	2.49 M	$\pm 1\%$
MG 650	2.0 M	$\pm 1\%$
MS 126	1.33 K	$\pm 1\%$

5.0 ENVIRONMENTAL

5.1 Temperature Cycle

Temperature cycle per MIL-STD-202D, Method 102A,
Test Condition C, and MIL-R-10509F, Paragraph
4.6.4.

5.2

Burn-In

Subject each resistor to a burn-in test for 168 hours under the following conditions:

Temperature - 125°C

Operate at rated power.

The resistance change shall not be more than 0.5% from initial measured value, or out of initial tolerance, before and after burn-in.

6.0

FINAL SCREEN

Measure and record resistance. Resistance shall be within $\pm 1\%$ of nominal and shall not change greater than $\pm 0.5\%$ from initial reading.

TABLE 1

ELECTRICAL AND
ENVIRONMENTAL TESTS

	Paragraph
Electrical	4.1
Environmental	
Temperature Cycle	5.1
Burn-in	5.2
Final Screen	6.0

cc:

SECTION 7

PROCUREMENT SPECIFICATION
FOR
CADDOK RESISTORS
TYPE 1712-100 MEG

Document Number EPS-168

Prepared by
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Houston, Texas
Under Contract NAS 9-11373
for
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PROCUREMENT SPECIFICATION
FOR

CADDOCK RESISTORS
TYPE 1712-100 MEG

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5.1 Temperature Cycle	7-6
5.2 Burn-In	7-6
6.0 FINAL SCREEN	7-6

1.0 SCOPE

This specification defines the high reliability requirements of resistors for the Electron-Proton Spectrometer. The components shall be subjected to the specified tests in the order given.

2.0 APPLICABLE DOCUMENTS

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

MIL-R-10509F, Resistor Fixed Film, General Specification For

MSCM 8080, Manned Spacecraft Center Standards and Criteria

3.0 QUALITY ASSURANCE REQUIREMENTS

3.1 Certificate of Compliance

A certificate of compliance signed by the Quality Control Manager shall be included with the device(s) shipment.

It shall verify that the resistors were processed in accordance with this specification, and that all requirements have been met.

3.2 Retention of Records

The part supplier shall maintain and preserve records of evidence of compliance for a period of one year from the date of acceptance of the item by LEC. The supplier shall make his records available upon request from LEC or NASA/MSC.

3.3 Traceability

The vendor shall assure that traceability required by Standard No. 86 in MSCM 8080 can be provided. Identification to the part production, assembly and test lot shall be recorded. All traceability information shall be supplied on request of LEC or NASA/MSC. This traceability requirement is for a one-way, backward traceability by part or lot code.

3.4 Preparation for Delivery

The resistors shall be packed in a suitable container which will protect the body and leads of the device during shipment.

4.0 ELECTRICAL TESTS

4.1 Electrical Parameters

Measure the following parameters and record the results on an appropriate data sheet beside the applicable serial number. Reject devices exceeding the limits shown.

- a. R (resistance) per method 302 of MIL-STD 202D.
Limit = +1% of designated value.
- b. IR (insulation resistance) per method 302 of MIL-STD 202D. VR = 200V, limit = 100,000 megohm minimum.

5.0 ENVIRONMENTAL

5.1 Temperature Cycle

Temperature cycle per MIL-STD 202D, Method 102A, Test Condition C, and MIL-R-10509F, Paragraph 4.6.4.

The parameters specified in Paragraph 4.1 shall be monitored. Any unit failing the electrical parameters shall be rejected.

5.2 Burn-In

Subject each resistor to a burn-in test for 168 hours under the following conditions:

Temperature - 125°C
Operate at rated power.

The resistance change shall not be more than 0.5% from initial measured value, or out of initial tolerance, before and after burn-in.

6.0 FINAL SCREEN

Measure and record resistance. Resistance shall be within +1% of nominal and shall not change greater than +0.5% from initial reading.

TABLE 1

ELECTRICAL AND
ENVIRONMENTAL TESTS

	Paragraph
Electrical	4.1
Environmental	
Temperature Cycle	5.1
Burn-In	5.2
Final Screen	6.0

PROCUREMENT SPECIFICATION
FOR
CAPACITOR (VARIABLE) RVC 12

Document Number EPS-232

Prepared by
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PROCUREMENT SPECIFICATION
FOR
CAPACITOR (VARIABLE) RVC 12

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5.4 Temperature Cycling	8-8
5.5 Vibration	8-8
5.6 Burn-in	8-10
5.7 External Visual	8-10

1.0

SCOPE

This specification defines the high reliability requirements of variable capacitors for the Electron-Proton Spectrometer. The components shall be subjected to the specified tests in the order given.

2.0

APPLICABLE DOCUMENTS

MIL-STD 202D, Test Methods for Electronic and Electrical Parts

MSCM 8080, Manned Spacecraft Center Criteria and Standards

3.0

RELIABILITY AND QUALITY ASSURANCE REQUIREMENTS

3.1

Certificate of Compliance

A certificate of compliance signed by the quality control manager shall be included with all units shipped. It shall verify that the units were manufactured in accordance with this specification and that all requirements have been met.

3.2

Traceability

The manufacturer will assure that traceability can be traced to the lot date and/or code of the lot the parts procured to this specification was taken from. All traceability information will be supplied to LEC and/or NASA/MSD upon request.

3.3

Record Retention

The part supplier shall maintain and preserve records of evidence of compliance and traceability for a period of one year from date of acceptance by LEC. The supplier shall make his records available upon request from LEC or NASA/MSC.

4.0

PREPARATION FOR DELIVERY

4.1

Unit Preparation and Packaging

Each unit procured to this specification shall be clean, dry and packaged individually. The manner of packaging will afford adequate protection against corrosion, deterioration and physical damage during shipment from supply source to the first receiving activity.

4.2

Packing

The packaged units shall be packed in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. This pack shall conform to the applicable carrier rules and regulations.

4.3

Marking

Each shipping container will be marked with the supplier's name and the part number.

5.0

ELECTRICAL AND ENVIRONMENTAL TESTS

5.1

Capacitance

Capacitors shall be tested in accordance with Method 305 of MIL-STD 202D. The following details shall apply.

- a. Test frequency - $1 \text{ MHz} \pm 100 \text{ kHz}$.
- b. Limit of accuracy - $\pm 2\%$ or 0.5 picofarad, whichever is greater.

5.2

Dissipation Factor

The dissipation factor of the capacitors shall be measured at both maximum and minimum capacitance setting at a frequency of $1 \text{ MHz} \pm 100 \text{ kHz}$. The accuracy of the measurement shall be at least 0.2%.

5.3

Dielectric Withstanding Voltage

Terminal to Terminal - Capacitors shall be tested in accordance with Method 301 of MIL-STD 202D. The following details shall apply:

- a. Magnitude of test voltage - 2.2 times applicable rated dc voltage.
- b. Duration of application of test voltage - 3, ± 2 seconds.
- c. Points of application of test voltage - between terminals.
- d. Limiting value of surge current - 50 milliamps.

5.3 (continued)

When measured as specified, capacitors shall withstand the dc current potential without damage, breakdown or flashover.

5.4 Temperature Cycling

Capacitors shall be tested in accordance with Method 102A, Test Condition C, MIL-STD 202D. Examination and measurements shall be made after final cycle.

Capacitors shall be examined visually for evidence of mechanical damage; dielectric withstanding voltage (paragraph 5.3), capacitance (paragraph 5.1) and dissipation factor (paragraph 5.2) shall be measured as specified in the referenced paragraphs.

5.5 Vibration

The capacitors shall be tested in accordance with MIL-STD 202D, Method 204, Condition B, one sweep from 15 to 2000 cycles, with a time duration of 10 minutes. The following details shall apply.

- a. Capacitors shall be rigidly mounted on a mounting fixture by normal mounting means. The mounting fixture shall be so constructed as to preclude any resonances within the test range.

5.5 (continued)

- b. Measurements prior to vibration - Capacitors shall be set at approximately 90% to 95% of maximum rated capacitance, and capacitance shall be measured to four places.
- c. Electrical-load conditions - During the test a potential of 125% of rated dc voltage shall be applied between the terminals of the capacitor.
- d. Test Condition - Letter B.
- e. Measurement during vibration - During the last cycle in each direction, an electrical measurement shall be made to determine intermittent contacts. Intermittent contacts of 0.5 ms or greater, or open or short circuiting shall be considered a failure.
- f. Examination after vibration - Capacitors shall be visually examined for evidence of mechanical damage.
- g. Final Measurements - After the final vibration cycle, the initial capacitance setting shall not be disturbed. The change in the initial setting as defined in paragraph 5.5b shall not exceed .03%. Dielectric withstanding voltage, capacitance and dissipation factor shall be measured as specified in paragraph 5.3, 5.1 and 5.2 respectively.

5.6

Burn-in

The capacitors shall be subjected to burn-in temperature of 125°C for 168 hours +16, -0 hours. The following operating conditions shall apply:

- a. The capacitors shall be subjected to the maximum rated voltage. The surge current shall not exceed 50 ma.
- b. Measurement during and after exposure: At the conclusion of this test and while the capacitors are still held at the maximum rated temperature, the dielectric withstanding voltage and capacitance shall be measured as specified in Paragraph 5.3 and 5.1 respectively. The capacitors shall be returned to normal temperature and visually examined for evidence of mechanical damage. The capacitance and dissipation factor shall be measured as specified in Paragraph 5.1 and 5.2 respectively.

5.7

External Visual

The dimensions of each device shall conform to the configuration shown in Figure 1.

ELECTRICAL AND ENVIRONMENTAL TESTS

	Paragraph
Capacitance	5.1
Dissipation Factor	5.2
Dielectric Withstanding Voltage	5.3
Temperature Cycling	5.4
Vibration	5.5
Burn-in	5.6
External Visual	5.7

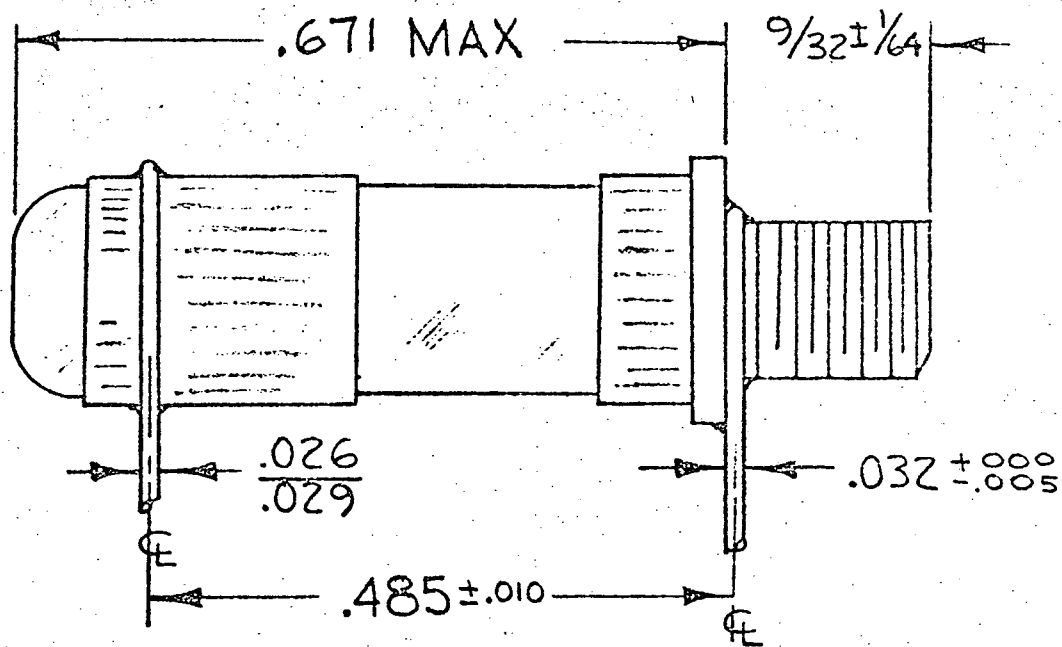


FIGURE 1. LEAD CONFIGURATION OF RVC 12

PROCUREMENT SPECIFICATION
FOR
NYTRONICS INDUCTOR
PD-100

Document Number EPS-167

Prepared by
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Under Contract NAS 9-11373
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PROCUREMENT SPECIFICATION
FOR
NYTRONICS INDUCTOR
PD-100

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5.6 Burn-In	9-7

1.0 SCOPE

This specification defines the high reliability requirements of Inductors for the Electron-Proton Spectrometer. The components shall be subjected to the specified tests in the order given.

2.0 APPLICABLE DOCUMENTS

MIL-STD 202D, Test Methods for Electronic and Electrical Parts

MSCM 8080, Manned Spacecraft Center Criteria and Standards

MIL-C-15305D, Coils, Fixed and Variable, General Specifications For

3.0 QUALITY ASSURANCE

3.1 Certificate of Compliance

A certificate of compliance signed by the quality control manager shall be included with all units shipped. It shall verify that the units were manufactured in accordance with this specification and that all requirements have been met.

3.2 Traceability

The Manufacturer will assure that traceability required by Standard 86 in MSCM 8080 can be provided. In addition, provisions will be made to record information relating to the specific tests performed and processes on each lot of parts. All traceability information will be supplied to LEC and/or NASA/MSD upon request.

3.3 Record Retention

The part supplier shall maintain and preserve records of evidence of compliance and traceability for a period of one year from date of acceptance by LEC. The supplier shall make his records available upon request.

4.0 PREPARATION FOR DELIVERY

4.1 Unit Preparation and Packaging

Each unit procured to this specification shall be clean, dry and packaged individually. The manner of packaging will afford adequate protection against corrosion, deterioration and physical damage during shipment from supply source to the first receiving activity.

4.2 Packing

The packaged units shall be packed in a manner that will afford adequate protection against damage during direct shipment from the supply source to the first receiving activity. This pack shall conform to the applicable carrier rules and regulations.

4.3 Marking

Each shipping container will be marked with the supplier's name and the part number.

4.4 Shipping Method

Unless otherwise specified, the supplier shall use his own delivery facilities if delivery is local, and air express if the distance is greater than 100 miles.

5.0 ELECTRICAL AND ENVIRONMENTAL TESTS

5.1 Dielectric Withstanding Voltage

The inductors shall be tested in accordance with Paragraph 4.8.2, MIL-C-15305D. There shall be no arcing, flash-over, breakdown, or other damage.

5.2 Insulation Resistance

The inductors shall be tested in accordance with Paragraph 4.8.4, MIL-C-15305D. The insulation resistance shall be not less than 1000 megohms.

5.3 "Q" of Inductors

The test shall be performed using a Q meter such as Boonton RCA Model 260A, or equivalent, and Boonton RCA Q-standard, type 513A or equivalent. The tests shall be performed in accordance with Paragraph 4.8.8.3 of MIL-C-15305D. The "Q" of the inductors shall be 55 minimum at a frequency of 2.5 mHz.

5.4 DC Resistance (DCR)

Direct Current Resistance of the inductors shall be measured in accordance with Method 303, MIL-STD 202D. Test Current (I_T) = 110 mA. The unit shall be considered failed if the DCR is greater than 11.5 ohms.

5.5 Temperature Cycling

Inductors shall be tested in accordance with Method 102 of MIL-STD 202D. The following details shall apply:

- a. Conditioning prior to first cycle - 15 minutes at standard temperature.

5.6 Burn-In

Inductors shall be tested in accordance with Method 108A of MIL-STD 202D. The following details shall apply:

- a. Test temperature - $125^{\circ}\text{C} \pm 3^{\circ}\text{C}$
- b. Length of Test - minimum of 168, +16, -0 hours

5.6.1 Operating Conditions

Inductors tested shall be subjected to the DC rated voltage. The rated current shall not be greater than 110 mA.

5.6.2 Measurements During and After Exposure

At the conclusion of this test and while the inductors are at the applicable test temperature, the insulation resistance shall be measured in accordance with Method 302, MIL-STD 202D, Condition C. The insulation resistance shall not be less than 1,000 megohms. The specimens shall be returned to 25°C and paragraph 5.1 through 5.4 shall be repeated.

PROCUREMENT SPECIFICATION
FOR
BARRY CONTROL VIBRATION ISOLATORS

LEC Document Number EPS-356

Revision A 5.2.1 (6.0 to 6.2)
Revision B 6.2 (by to to)

Prepared by
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PROCUREMENT SPECIFICATION
FOR
BARRY CONTROLS VIBRATION ISOLATOR

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PROCUREMENT SPECIFICATION FOR
BARRY CONTROLS VIBRATION ISOLATORS

1.0 SCOPE

1.1 Scope

This specification defines necessary procurement requirements for the Barrymount 6300 Series Isolator, to satisfy design requirements and NASA Reliability and Quality Assurance provisions for the Electron-Proton Spectrometer.

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application should form a part of this specification to the extent specified herein.

NBH 5300.4(1B) Reliability and Quality Assurance Provisions for Aeronautical and Space System Contractors.

3.0 QUALITY ASSURANCE REQUIREMENTS

3.1 Inspection, Measuring and Test Equipment

The vendor shall maintain and control inspection, measuring and test equipment in accordance with paragraph 1B705 of NHB 5300.4(1B).

3.2 Inspection and Test Records

Inspection and test records shall include part number, identification of each mount and each set of isolators, number of defects found, kind of defects, and acceptance number. Records of inspection and tests shall be delivered to Lockheed.

3.3 Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with the device shipment. It shall verify that the isolators were processed in accordance with this specification and that all requirements have been met.

3.4 Retention of Records

The part supplier shall maintain and preserve records of evidence of compliance for a period of one year from the date of acceptance of the item by LEC. The supplier shall make his records available upon request from LEC or NASA/ MSC.

3.5 Traceability

The vendor shall assure that traceability required by Standard No. 86 in MSCM 8080 can be provided. Identification to the part production, assembly and test lot shall be recorded. All traceability information shall be supplied on request of LEC or NASA/MS. This traceability requirement is for a one-way, backward traceability by part or lot code.

3.6 Preparation for Delivery

The isolators shall be packaged in a suitable container which will protect the body of the device during shipment.

4.1 Physical Requirements

4.1.1 The vibration isolator required shall be of the proportions of the Barrymount 6300 series isolator. However, the mounting flanges shall be modified to the dimensions shown in Fig. 4. Also, the spacer end plates shall be of the dimensions shown in Fig. 4A.

4.1.2 Material

The vibration isolators shall be made from silicone material which is 'Hi-Damp' Elastomer. Material shall be compatible with orbital vacuum (as low as 1×10^{-8} Torr). Maximum Mission duration is 56 days.

4.1.3 Package Format

The EPS electronics package as supported on the isolators will weigh 15.5 lbs. MAX., and be supported by 8 isolators. The location of the isolators, together with the size and C. G. position of the package is shown in Fig. 5.

4.1.4 Dynamic Envelope

Maximum permissible dynamic envelope for the package is shown in Fig. 6.

4.1.5 System (Mount) Natural Frequency

The system natural frequency shall be designed for 40 Hz and must fall in the frequency range of 35 - 50 Hz.

4.1.6 Damping Ratio

Desired Damping Ratio is .15, and shall not be less than .12.

4.1.7 Central Bush

The Centre Bush shall be capable of withstanding a load of 1700 lbs. (induced by the mounting screw tightening torque) without failure or affecting mount properties.

4.1.8 Matching

The mounts shall be provided in matched sets of (8) eight to eliminate as far as possible 'rocking' induced by variations in mount stiffness.

4.1.9 Mounts shall be marked and identified individually.

5.0 TESTING

5.1 All vibration isolation mounts shall be tested to determine their natural frequency and damping ratio in both vertical and horizontal axes, and this information provided to LEC.

5.2 Dynamic Testing

5.2.1 Isolation mounts shall be dynamically tested to the environmental requirements of 6.2. This test data shall be used to select the location of individual isolators within each matched set. Location of mounts and test data to be provided to LEC with matched sets of mounts.

5.3 Temperature Testing

5.3.1 The mounts must meet or exceed a temperature environment of -55°C to $+125^{\circ}\text{C}$. The mounts shall be tested or available data analyzed to show that the mounts meet this requirement. Supporting data shall be furnished to LEC.

6.0 ENVIRONMENTAL REQUIREMENTS

6.1 Vibration

6.1.1 Random Vibration

The Random Vibration Criteria imposed on the EPS are as follows:

QUALIFICATION

R-Axis

20 to 125 Hz	+12 dB/oct increase
125 to 500 Hz	$2.0\text{ g}^2/\text{Hz}$
500 to 670 Hz	-9 dB/oct decrease
670 to 1100 Hz	$0.8\text{ g}^2/\text{Hz}$
1100 to 2000 Hz	-9 dB/oct decrease

X-Axis

20 to 75 Hz	+6 dB/oct increase
75 to 175 Hz	$0.085\text{ g}^2/\text{Hz}$
175 to 300 Hz	+6 dB/oct increase
300 to 1000 Hz	$0.25\text{ g}^2/\text{Hz}$
1000 to 2000 Hz	-6 dB/oct decrease

T-Axis

20 to 100 Hz	+6 dB/oct increase
100 to 440 Hz	$0.04 \text{ g}^2/\text{Hz}$
440 to 600 Hz	+18 dB/oct increase
660 to 900 Hz	$0.3 \text{ g}^2/\text{Hz}$
900 to 2000 Hz	-12 dB/oct decrease

The excitation shall act along each of the above axes for a duration of 140 seconds per axis. In addition, the spectral density shall be increased by 4 dB above the nominal for a duration of 10 seconds per axis. (See Fig. 1 for Instrument Axes)

One isolator shall be subjected to the dynamic response of the listed vibration criteria. The remaining isolators shall be qualified by similarity. The data from the analysis shall be sent to LEC.

6.1.2 Flight: 20 - 100 Hz	+3 dB/octave (increasing)	Total Duration -12 1/2 mins/Axis.
100 - 2000 Hz	Constant at $0.15 \text{ g}^2/\text{Hz}$.	

6.2 Sinusoidal

5-35 Hz @ .25 G peak along each of three orthogonal axes as follows: Sweep at 3 octaves per minute from 5 to 35 to 5 Hz.

The sinusoidal vibration test shall be accomplished on 100% of the isolators furnished to LEC.

6.3 Acceleration

The EPS is subjected to a gradually increasing acceleration load in the +X Axis for 140 seconds after lift-off. Fig. 2 shows the acceleration level versus time. The 10 second, 4 dB above nominal, burst occurs just prior to achieving Mach. 1, and its location relative to the acceleration level is also shown in Fig. 2.

One isolator shall be subjected to the dynamic response of the listed acceleration tests. The remaining isolators shall be qualified by similarity. The results of the analysis will be sent to LEC.

6.4 Shock

6.4.1 Test Shock

The EPS Shock Test is in accordance with MIL-STD-810B, Method 516, Procedures I and V. The shock pulse shape for Procedure I shall be as shown in Fig. 516 -1 of MIL-STD-810B. The peak value for Procedure I shall be 20 g. and the nominal duration of the pulse shall be 11 milliseconds.

Procedure I consists of three shocks in each direction applied along three mutually perpendicular axes of the test item (total of 18 shocks). The shock pulse shall be of a saw tooth shape with an amplitude of 20 g's and a duration of 11 milliseconds. The unit shall be operated after the test and the results compared with functional test results obtained before the shock test.

Procedure V consists of placing the unit on a wooden bench top at least 1 5/8 inches thick and performing the following: With the unit resting on its one flat surface lift one edge of the unit four inches and allow the unit to drop back freely to the horizontal bench top. Repeat using the other three edges as pivot points for a total of four drops. Functionally test unit and compare with previous test results.

One isolator shall be subjected to the dynamic response of the shock criteria listed below. The remaining isolators shall be qualified by similarity. The results of the analysis shall be sent to LEC.

6.4.2 Flight Shock

In addition to the Test Shock conditions of Para. C.1, the EPS is mounted in the command and service module fairing area. The pyrotechnic separation of the (SLA) from the CSM provides a shock response spectrum as shown in Fig. 3.

The Flight Shock shall be proven by analysis. A summary of the resulting data shall be sent to LEC.

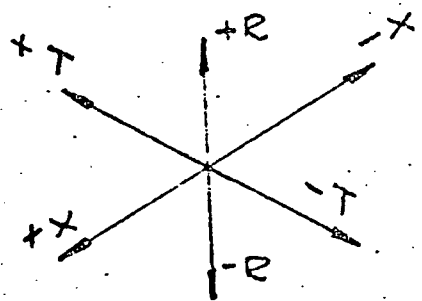
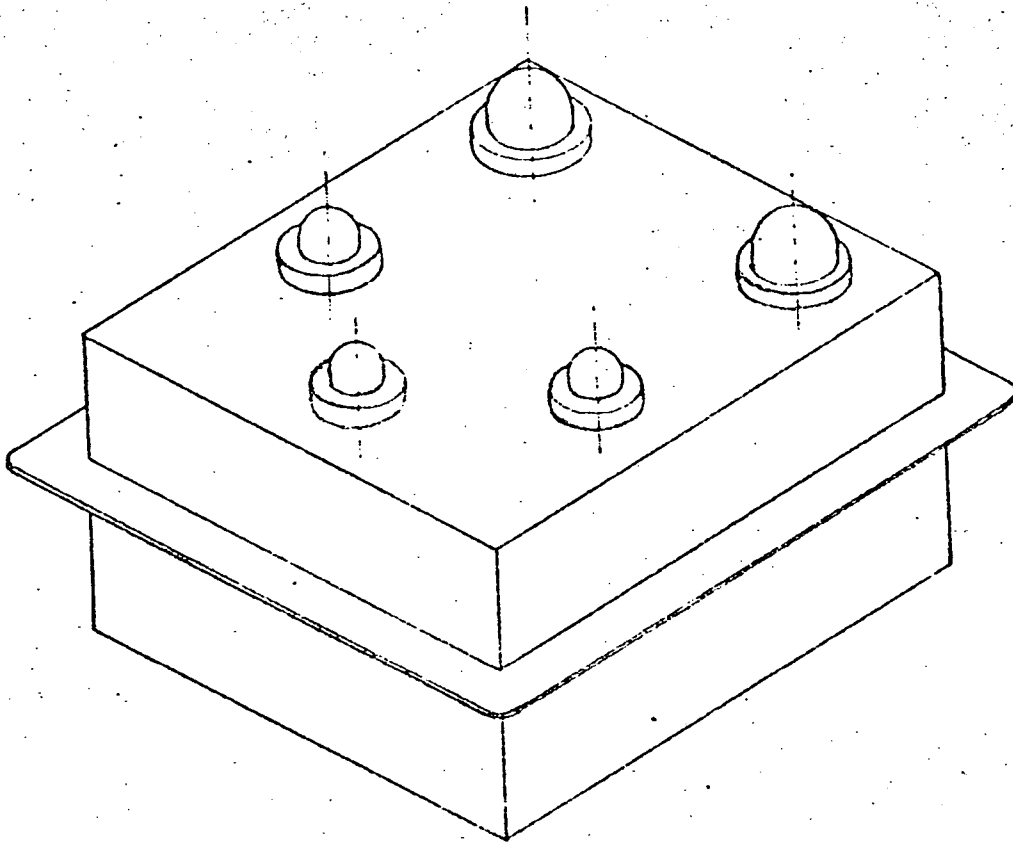


FIG. 1 E.P.S. VIBRATION AXES.

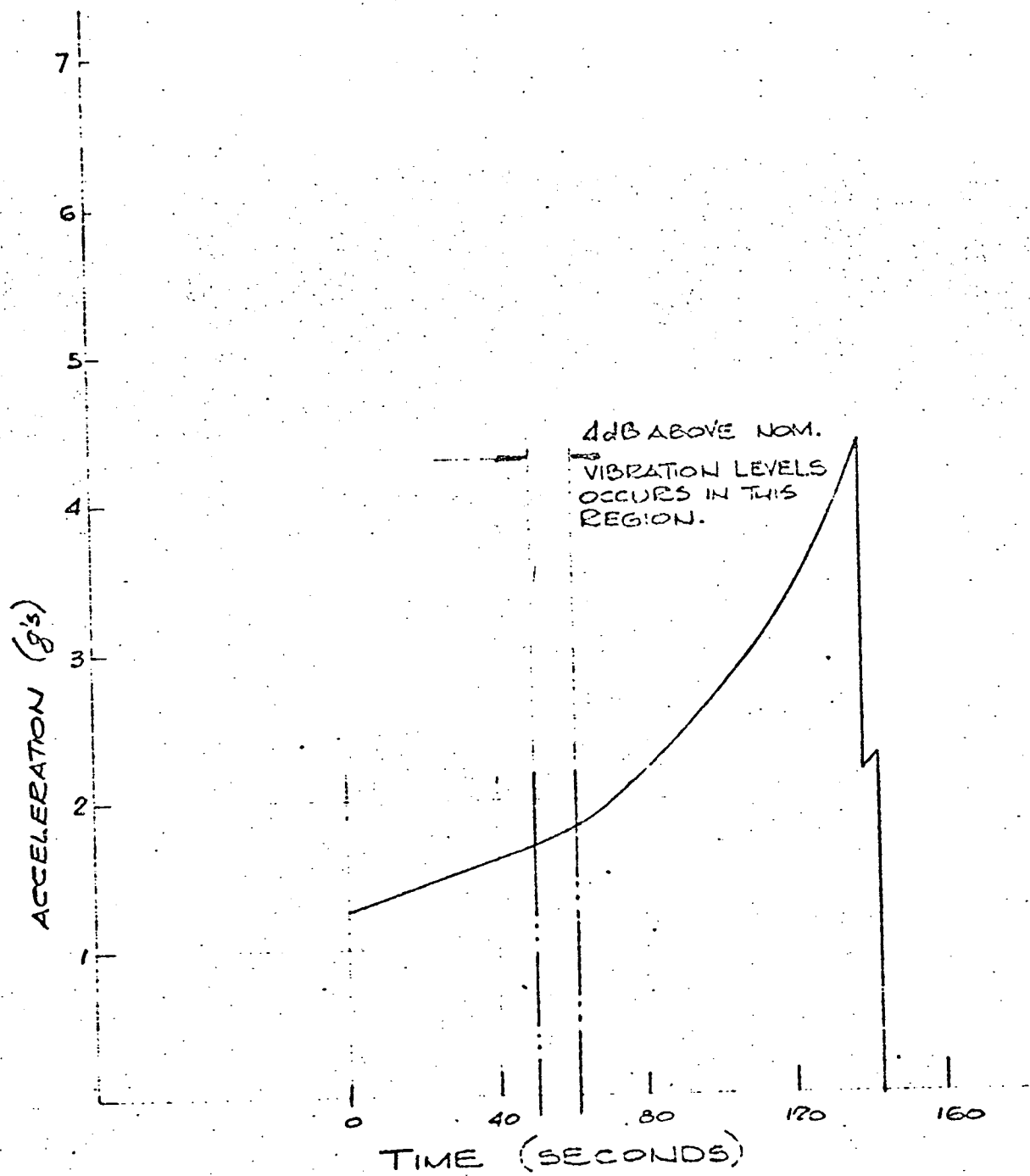


FIG 2. ACCELERATION v TIME.

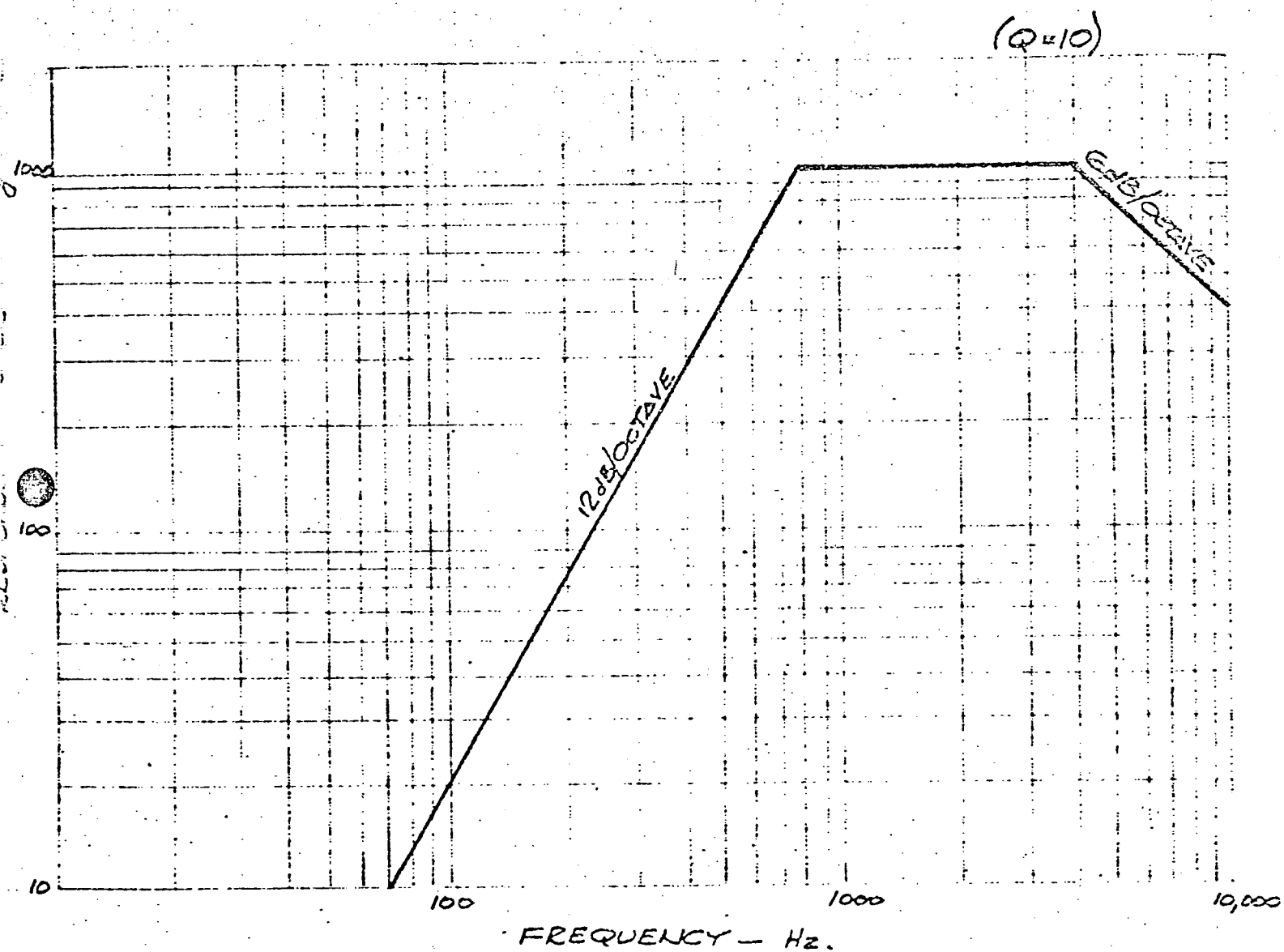


FIG. 3. CSM FAIRING-SHOCK RESPONSE SPECTRUM.

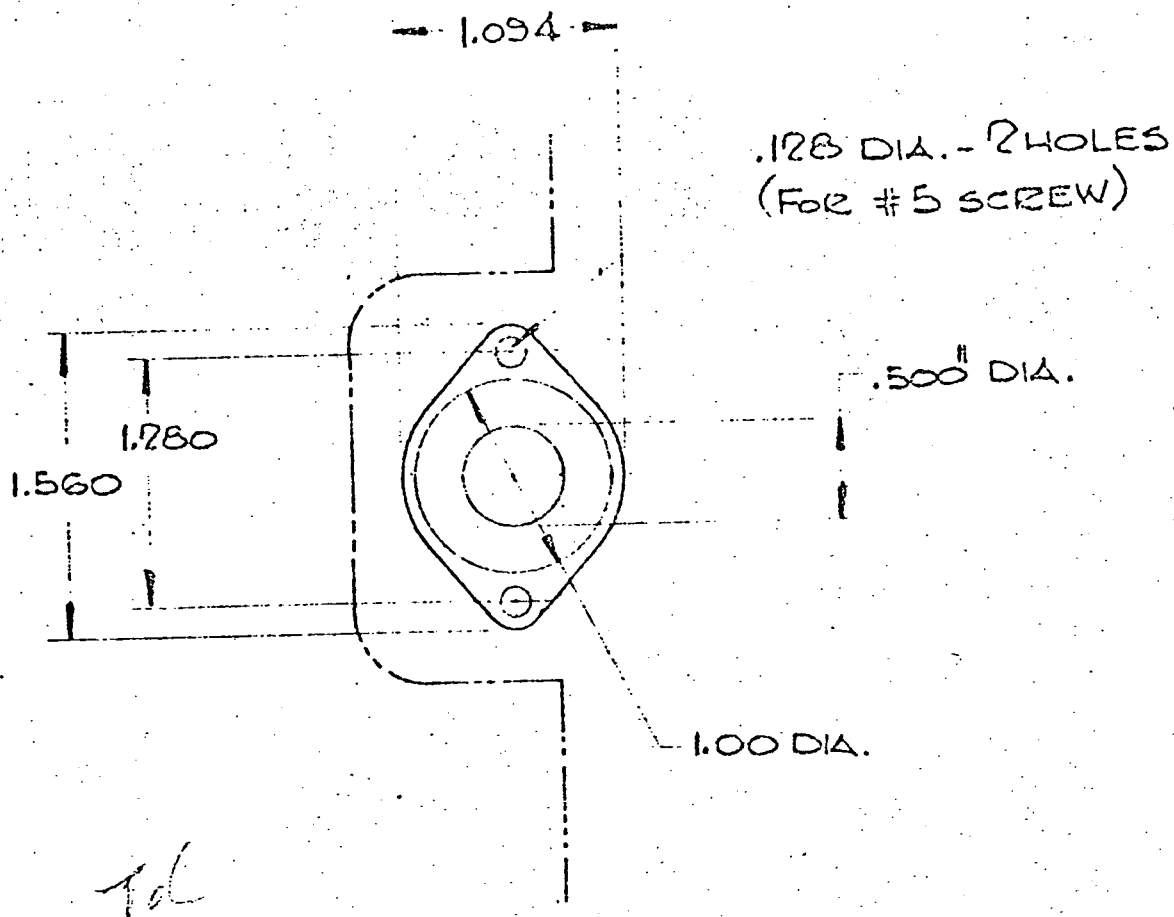


FIG.4. REQUIRED VIBRATION ISOLATOR
PROFILE — ELECTRON-PROTON
SPECTROMETER.

QY 8-17-71
LOCKHEED ELECTRONICS
HOUSTON, TEXAS.

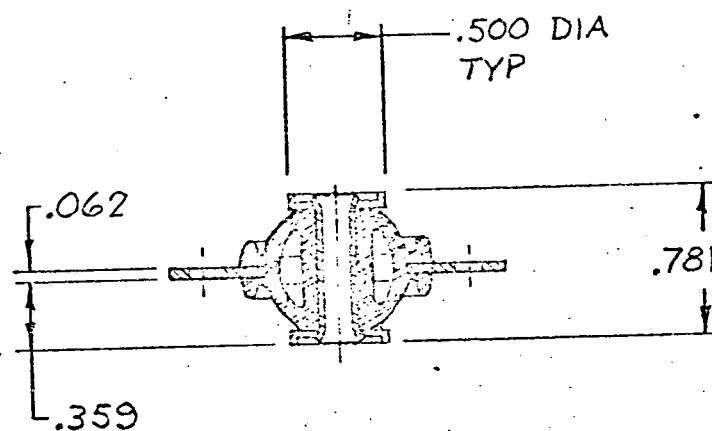


FIG. 4a - REQUIRED HEIGHT AND
FLANGE POSITION FOR
ISOLATOR - ELECTRON-PROTON
SPECTROMETER.

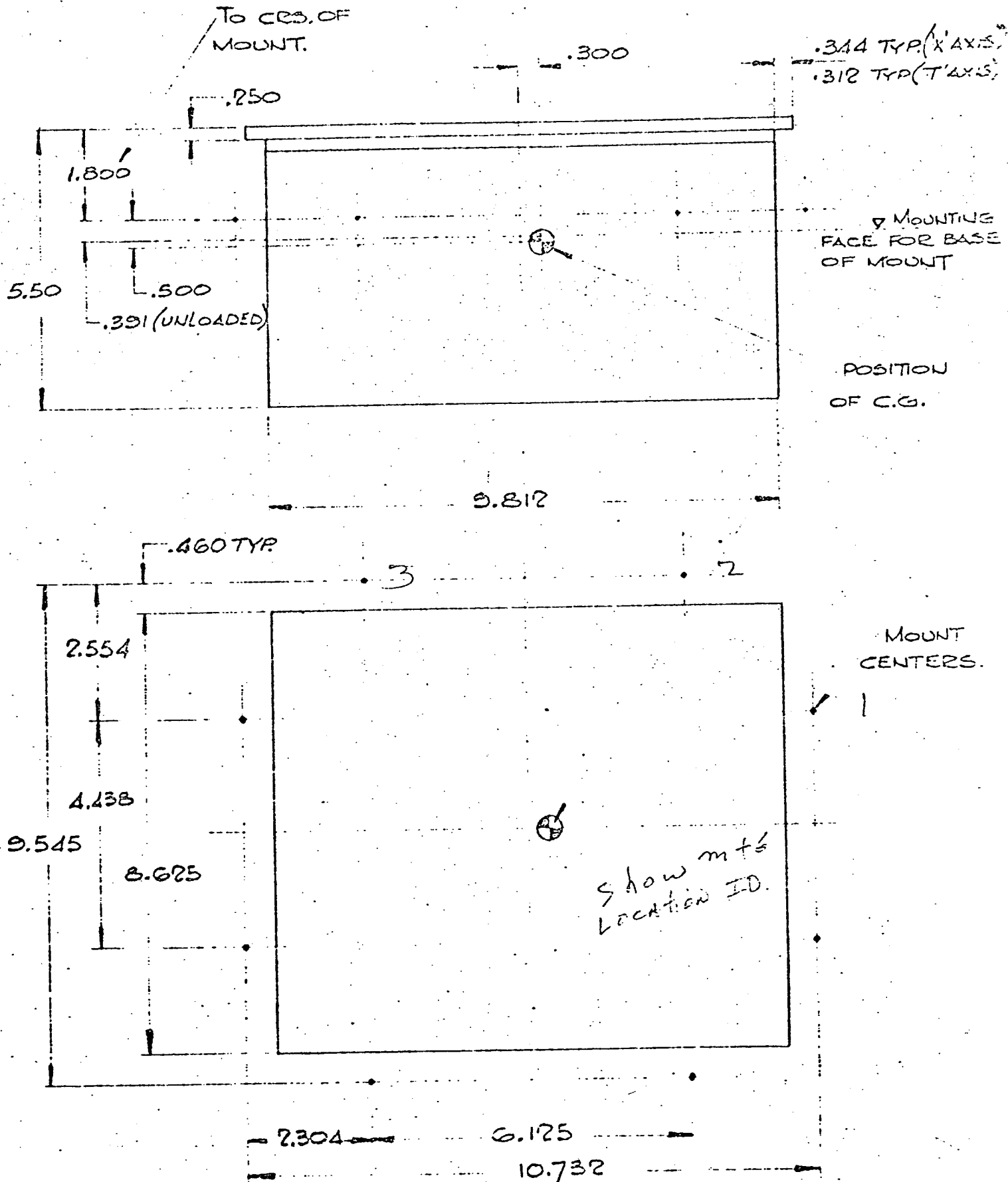
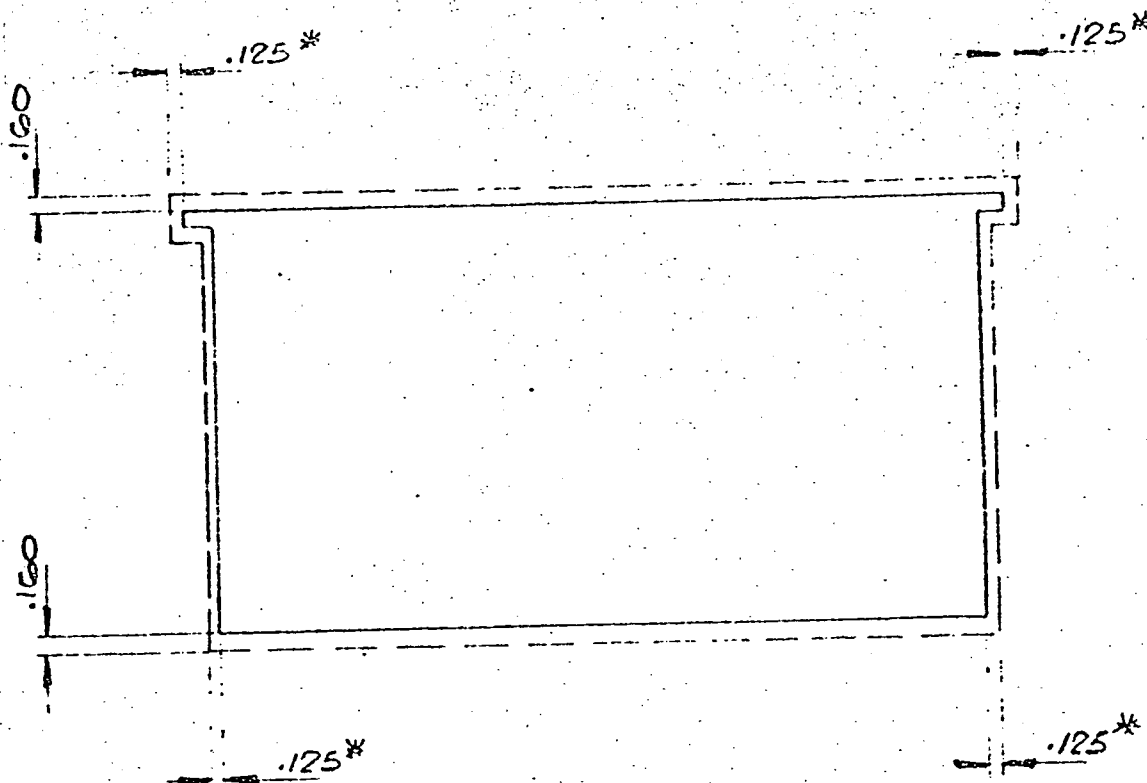


FIG.5

VIBRATION MOUNT LOCATION.



* DIMS. APPLY TO 'X' & 'T' AXES

FIG. 6 MAXIMUM ALLOWABLE
DYNAMIC ENVELOPE.

SECTION 10

SCREENING SPECIFICATION
FOR
TRANSISTOR SS3520

Document Number EPS-128

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

SCREENING SPECIFICATION
FOR
TRANSISTOR SS 3520

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1.0

SCOPE

This document defines the necessary requirements for the screening of transistor SS3520 to satisfy NASA high reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0

APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 202D, Test Methods for Electronic and Electrical component parts

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 883, Test Methods and Procedures for Microelectronics

NHB 5300.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0

REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1

Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2

Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with

3.2 (continued)

NHB 5300.4 (1A). Upon request, the subcontractor shall submit to Lockheed Electronics Company (LEC) for approval, a listing of equipment and their intended usage.

3.3

Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration, shall be displayed on each item of this equipment.

3.4

Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0

RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1

General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD-202D.

4.2

Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table 1.

4.3

Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted with the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4

Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5

Serialization

All transistors shall be serialized in a manner that will be permanent during use and testing periods.

4.6 Reject Disposition

Each transistor that fails the inspections and tests of Table 1 shall be marked with a red dot and placed in a reject bag, and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use 3M-401-5D paint for marking of parts.

4.7 Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed on the body at a point which will not interfere with reading the manufacturers part number or date code identification. Use 3M-401-G3 paint for marking of parts.

4.8 Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9 Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with the device shipment. It shall verify that the transistors

4.9 (continued)

were processed in accordance with this specification and that all requirements have been met.

4.10 Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0 PREPARATION FOR DELIVERY

5.1 Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2 Packaging for Shipment

The transistors packaged in accordance with paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carrier's rules and regulations applicable to the mode of transportation.

6.0 INSPECTION AND TEST METHODS

6.1 External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2 Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted.

6.2.1 Collector-Base Cutoff Current

$$V_{CB} = 15 \text{ VDC}$$

$$I_E = 0$$

The collector-base cutoff current shall be tested in accordance with Method 3036, Condition D, MIL-STD 750A.

The unit shall be considered failed if the I_{CBO} is greater than 10 nA dc.

6.2.2 Collector - Base Breakdown Voltage

$$I_C = 1.0 \text{ } \mu\text{A dc}$$

6.2.2 (continued)

$$I_E = 0$$

The collector - base breakdown voltage shall be tested in accordance with Method 3001.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if BV_{CBO} is less than 35 VDC.

6.2.3 Emitter - Base Breakdown Voltage

$$I_E = 10 \mu A \text{ dc}$$

$$I_C = 0$$

The emitter - base breakdown voltage shall be tested in accordance with Method 3026.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{EBO} is less than 3.0 VDC.

6.2.4 Collector - Emitter Breakdown Voltage

$$I_C = 3.0 \text{ mA dc (pulsed)}$$

$$I_B = 0$$

$$\text{Pulse width} \leq 300 \mu s$$

$$\text{Duty Cycle} = 1\%$$

6.2.4 (continued)

The collector - emitter breakdown voltage shall be tested in accordance with Method 3011.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{CEO} is less than 20 VDC.

6.2.5 Forward Current Ratio (h_{fe})

$$V_{CE} = 15 \text{ VDC}$$

$$I_C = 2.0 \text{ mA dc}$$

$$f = 1.0 \text{ kHz}$$

The forward transfer ratio shall be tested in accordance with Method 3206, MIL-STD 750A.

The unit shall be considered failed if the h_{fe} is less than 100.

6.2.6 Base - Emitter Saturation Voltage

$$I_C = 10 \text{ mA dc}$$

$$I_B = 1.0 \text{ mA dc}$$

The base-emitter saturation voltage shall be tested in accordance with Method 3066.1, MIL-STD 750A.

6.2.6 (continued)

The unit shall be considered failed if the $V_{BE}^{(Sat)}$ is greater than 1.0 VDC.

6.2.7 Collector - Emitter Saturation Voltage

$$I_C = 10 \text{ mA dc}$$

$$I_B = 1.0 \text{ mA dc}$$

The collector - emitter saturation voltage shall be tested in accordance with Method 3071.1, MIL-STD 750A.

The unit shall be considered failed if the $V_{CE}^{(Sat)}$ is greater than 0.4 VDC.

6.2.8 Unity Gain Frequency

$$V_{CE} = 15 \text{ VDC}$$

$$I_C = 1 \text{ mA}$$

$$f = 100 \text{ MHz}$$

The Unity Gain (f_t) shall be tested in accordance with Method 3261, Use, Method 3306.1, Condition A to determine the magnitude of the common emitter small-signal short-circuit transfer ratio. The unit shall be considered failed if the f_t is less than 500 MHz.

6.3 Electrical Intermediate

6.3.1 Forward - Current Transfer Ratio (h_{FE})

$$V_{CE} = 2.0 \text{ VDC}$$

$$I_C = 2.0 \text{ mA dc (pulsed)}$$

$$\text{Pulse Width} = 300 \text{ } \mu\text{s}$$

6.3.1 (continued)

Duty Cycle = 1%.

The forward current transfer ratio (h_{FE}) shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 75.

6.4 Environmental

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C, +0°C, -10°C, for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig, \pm 10 psig, in a helium atmosphere for a minimum period of four hours.

6.4.4 (continued)

The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak rates in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 883D, Method 1014, Condition C, at a temperature of $125^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each transistor shall be tested in accordance with MIL-STD 202D, Method 204A, Cond. C. The following shall apply:

1. Non-operating
2. Perform 2.4.2 part 2 only. The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes.
3. Paragraph 6.3, Electrical Intermediate, shall be run after completion of vibration testing.

6.5 Burn-In

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink whose temperature will be maintained at 70°C , $+15^{\circ}\text{C}$, -5°C .

6.5.2 Test Conditions

The collector to emitter voltage V_{CE} shall be set at 10 volts. The collector current I_C shall be set to 15 mA dc.

6.5.3 Test Length

The test shall be run for 168 hours, +12, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed. Prior to the testing of Section 6.2, the transistor shall be allowed to return to ambient temperature (25°C).

6.6 Radiographic Examination

6.6.1 Procedure

The transistor shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 100X minimum magnification, and reject units having the following defects or characteristics:

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: any unit displaying extraneous or foreign material that is not a normal portion of the product.

6.6.2 (continued)

- c. Bonds and bond wires: any bond or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

TABLE I
ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.	Electrical	Para. 6.2
2.	Environmental	Para. 6.4
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2.2	Electrical	Para. 6.3
2.3	Temperature Cycling	Para. 6.4.2
2.4	Electrical	Para. 6.3
2.5	Fine Leak	Para. 6.4.4
2.6	Gross Leak	Para. 6.4.5
2.7	Electrical	Para. 6.3
2.8	Vibration	Para. 6.4.6
2.9	Burn-In	Para. 6.5
2.10	Radiographic Examination	Para. 6.6

SECTION 11.

SCREENING SPECIFICATION
FOR
TRANSISTOR 2N2609

Document Number EPS-214

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

SCREENING SPECIFICATION
FOR
TRANSISTOR 2N2609

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Electron-Proton Spectrometer Program
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1.0 SCOPE

This document defines the necessary requirements for the screening of transistor 2N2609 to satisfy NASA high reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

NHB5300.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0 REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1 Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2 Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with NHB5300.4 (1A). Upon request, the subcontractor shall submit to

3.2 (continued)

Lockheed Electronics Company (LEC) for approval, a listing of equipment and their intended usage.

3.3 Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration shall be displayed on each item of this equipment.

3.4 Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0 RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1 General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD 202D.

4.2 Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table 1.

4.3 Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted with the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4 Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5 Serialization

All transistors shall be serialized in a manner that will be permanent during use and testing periods.

4.6 Reject Disposition

Each transistor that fails the inspections and tests of Table 1 shall be marked with a red dot and placed in a reject bag, and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use 3M Company's 3M-401-5D paint for marking of parts.

4.7 Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed on the body at a point which will not interfere with reading the manufacturer's part number or date code identification. Use 3M Company's 3M-401-G3 paint for marking of parts.

4.8 Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9 Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with the device shipment. It shall verify that the transistors were processed in accordance with this specification and that all requirements have been met.

4.10 Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0 PREPARATION FOR DELIVERY

5.1 Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2 Packaging for Shipment

The transistors packaged in accordance with paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carrier's rules and regulations applicable to the mode of transportation.

6.0 INSPECTION AND TEST METHODS

6.1.1

6.1 External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2 Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted.

6.2.1 Gate-Source Reverse Current

$$V_{DS} = 0$$

$$V_{GS} = -5 \text{ V}$$

6.2.1 (continued)

Connect the transistor as shown in Figure 1. The specified DC voltage shall be applied between the gate and the source with the drain connected to the source.

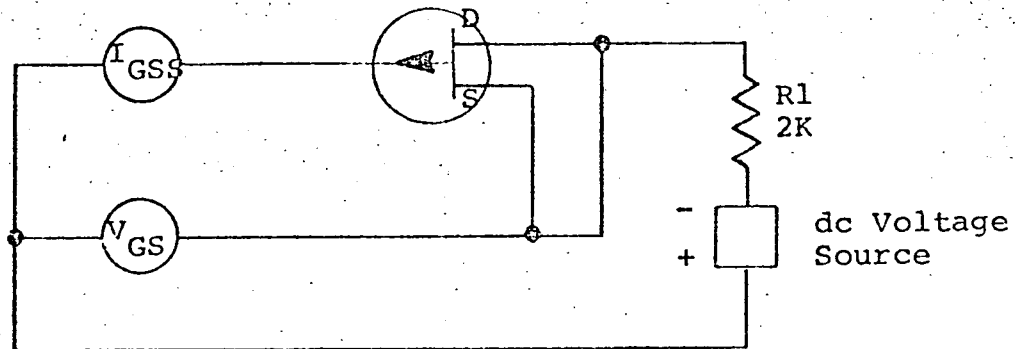


FIGURE 1

The unit shall be considered failed if the I_{GSS} is greater than 30 nA.

6.2.2 Gate-Drain Breakdown Voltage

$$I_G = 1 \mu A$$

$$V_{DS} = 0$$

Connect the transistor as shown in Figure 2.

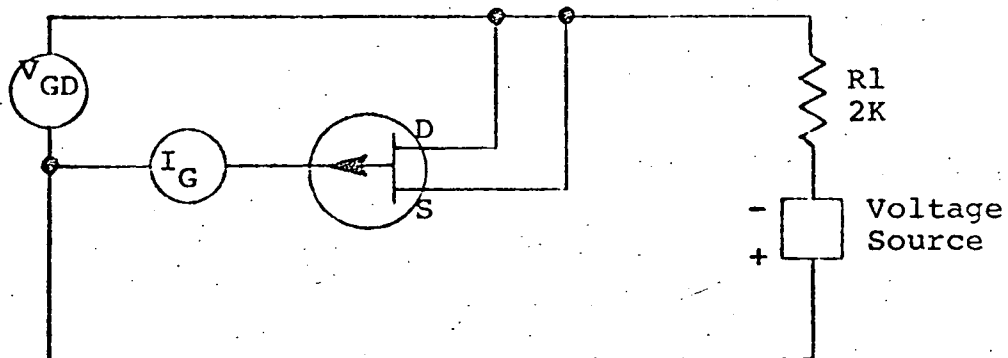


FIGURE 2

6.2.2 (continued)

The voltage shall be gradually increased from zero to the specified minimum value of $BV_{GDS} = 30V$ or until the specified gate current is reached. The device is acceptable if the specified limit for BV_{GDS} is reached before the current reaches the specified value. If the specified current is reached first, the device is rejected.

6.2.3 Drain Current at Zero Gate Voltage

$$V_{DS} = -5V$$

$$V_{GS} = 0$$

Connect the transistor as shown in Figure 3.

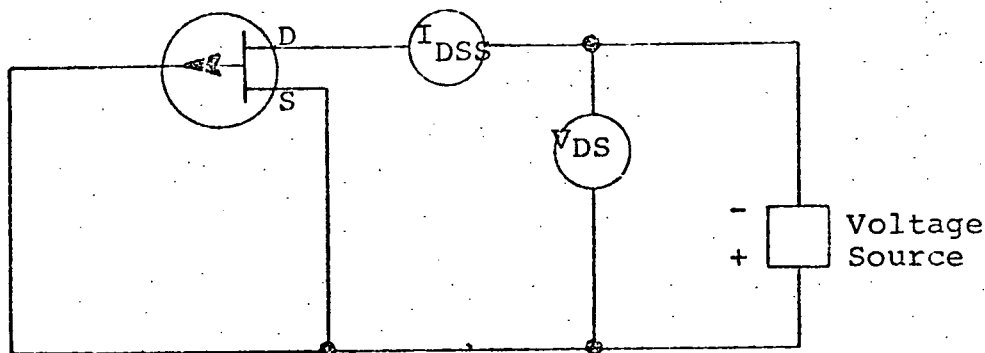


FIGURE 3

The specified drain to source voltage is applied. The device is accepted if the drain current I_{DSS} falls between the following values:

$$I_{DSS}(\text{min}) = 2.0 \text{ mA}$$

$$I_{DSS}(\text{max}) = 10.0 \text{ mA}$$

6.2.4 Gate-Source Pinch-Off Voltage

$$V_{DS} = -5V$$

$$I_D = 1 \mu A$$

Connect the transistor as shown in Figure 4.

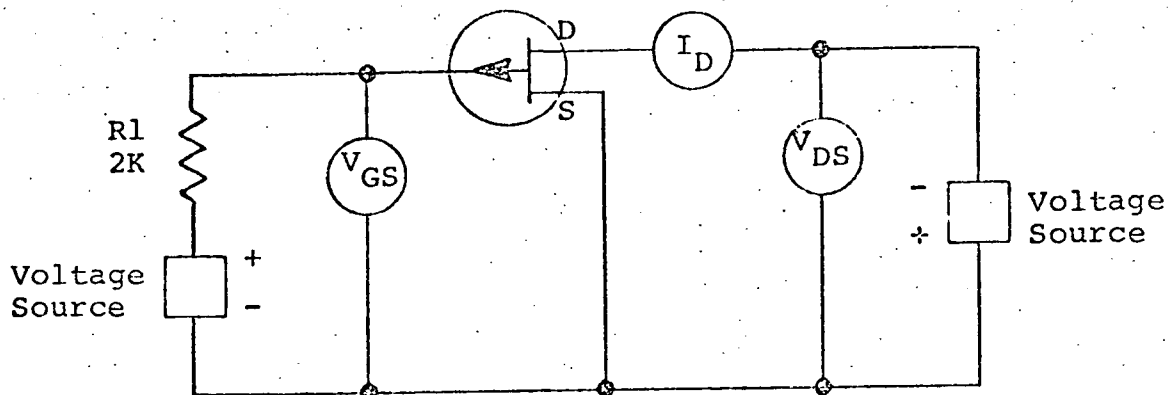


FIGURE 4

The drain-to-source voltage is applied and the gate-to-source voltage increased until the drain current reads 1 μA , for $V_p(\min)=1V$, $V_p(\max)=4V$. The device is acceptable if the gate-to-source voltage (V_p) falls within the specified limits.

6.3 Intermediate Electrical

6.3.1 Drain-Current at Zero-Gate Voltage

$$V_{DS} = -5V$$

$$V_{GS} = 0$$

6.3.1 (continued)

Connect the transistors as shown in Figure 3. The specified V_{DS} is applied. The device is acceptable if the drain current (I_{DSS}) falls between $I_{DSS}(\min) = 2.0 \text{ mA}$ and $I_{DSS}(\max) = 10.0 \text{ mA}$.

6.3.2 Gate-Source Reverse Current

$$V_{GS} = 5 \text{ V}$$

$$V_{DS} = 0$$

Connect transistor as shown in Figure 1. The specified DC voltage shall be applied between the gate and the source with the drain connected to the source. The device is considered failed if the I_{GSS} is greater than 30 nA.

6.4 Environmental

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C $+0^{\circ}\text{C}$, -10°C for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig \pm 10 psig, in a helium atmosphere for a minimum period of four hours. The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak rates in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition A, using ethylene glycol at a temperature of 125°C, \pm 10°C. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each device shall be tested in accordance with MIL-STD 202D, Method 204A, Condition C. The following shall apply.

1. Non-operating

2. Perform 2.4.2, Part 2 only

- (a) The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes

6.4.6 (Continued)

3. Paragraph 6.3, Electrical Intermediate, shall be run after completion of vibration testing.

6.5 Burn-In

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink whose temperature will be maintained at 70°C, +15°C, -5°C.

6.5.2 Test Conditions

$$V_{DS} = -5V$$

$$I_D = I_{DSS}$$

6.5.3 Test Length

The test shall be run for 168 hours, +12 hours, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed.

6.6 Radiographic Examination

6.6.1 Procedure

The transistor shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 100X minimum magnification, and reject units having the following defects or characteristics.

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: any unit displaying extraneous or foreign material that is not a normal portion of the product.
- c. Bonds and bond wires: any bond or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

TABLE I

ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.0	Electrical	Para. 6.2
2.0	Environmental	Para. 6.4
2.1	High Temperature Storage	Para. 6.4.1
2.2	Electrical Intermediate	Para. 6.3
2.3	Temperature Cycling	Para. 6.4.2
2.4	Electrical	Para. 6.2
2.5	Fine Leak	Para. 6.4.4
2.6	Gross Leak	Para. 6.4.5
2.7	Electrical	Para. 6.2
2.8	Vibration	Para. 6.4.6
2.9	Burn-In	Para. 6.5
2.10	Radiographic Examination	Para. 6.6

SECTION 12

SCREENING SPECIFICATION
FOR
TRANSISTOR 2N5333

Document Number EPS-179

Prepared by
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Under Contract NAS 9-11373
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SCREENING SPECIFICATION
FOR
TRANSISTOR 2N5333

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1.0 SCOPE

This document defines the necessary requirements for the screening of Transistor 2N5333 to satisfy NASA high reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 883, Test Methods and Procedures for Microelectronics

NHB53-0.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0 REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1 Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2 Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with NHB5300.4(1A). Upon request, the subcontractor shall submit to Lockheed Electronics Company (LEC) for approval, a listing of equipment and their intended usage.

3.3 Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration, shall be displayed on each item of this equipment.

3.4 Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0 RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1 General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD 202D.

4.2 Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table 1.

4.3 Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted with

4.3 (continued)

the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4 Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number, and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5 Serialization

All transistors shall be serialized in a manner that will be permanent during use and testing periods.

4.6 Reject Disposition

Each transistor that fails the inspections and tests of Table 1 shall be marked with a red dot and placed in a reject bag, and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use Minnesota Mining and Manufacturing Co's 3M-401-5D paint for marking of parts. Mixing and application should be done in accordance with manufacturer's specification sheet.

4.7 Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed

4.7 (continued)

on the body at a point which will not interfere with reading the manufacturer's part number or date code identification. Use Minnesota Mining and Manufacturing Co's 3M-401-G3 paint for marking of parts. Mixing and application should be done in accordance with manufacturer's specification sheet.

4.8 Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9 Certificate of Compliance

A certificate of compliance signed by the Quality Control Manager shall be included with the device shipment. It shall verify that the transistors were processed in accordance with this specification and that all requirements have been met.

4.10 Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0 PREPARATION FOR DELIVERY

5.1 Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2 Packaging for Shipment

The transistors packaged in accordance with Paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carrier's rules and regulations applicable to the mode of transportation.

6.0 INSPECTION AND TEST METHODS

6.1 External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2 Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted.

6.2.1 Collector Cutoff Current

$$V_{CE} = -40 \text{ VDC}$$

$$I_B = 0$$

6.2.1 (continued)

The collector cutoff current shall be tested in accordance with Method 3036, Condition D, MIL-STD 750A.

The unit shall be considered failed if the I_{CEO} is greater than $-50 \mu\text{A}$ dc.

6.2.2 Collector-Emitter Breakdown Voltage

$$I_C = -30 \text{ mA (pulsed)}$$

$$I_B = 0$$

$$\text{Pulse Width} = 300 \mu\text{s}$$

$$\text{Duty Cycle} = 1\%$$

The collector-emitter breakdown voltage shall be tested in accordance with Method 3001.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if BV_{CEO} is less than -80 VDC .

6.2.3 Emitter-Base Voltage

$$V_{CE} = -4 \text{ VDC}$$

$$I_C = -2\text{A}$$

$$\text{Pulse Width} = 300 \mu\text{sec}$$

$$\text{Duty Cycle} = 1\%$$

The emitter-base voltage shall be tested in accordance with Method 3026.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the V_{BE} is greater than -1.5 VDC .

6.2.4 Emitter Cutoff Current

$$V_{EB} = -4V$$

$$I_C = 0$$

The emitter cutoff current shall be tested in accordance with Method 3061.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the I_{EBO} is greater than $-1 \mu A$.

6.2.5 Forward-Current Transfer Ratio (h_{FE})

$$V_{CE} = -4 \text{ VDC}$$

$$I_C = -1 \text{ ADC (pulsed)}$$

$$\text{Pulse Length} = 300 \mu s$$

$$\text{Duty Cycle} = 1\%$$

The forward current transfer ratio shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 30.

6.2.6 Collector-Emitter Saturation Voltage

$$I_C = -1.0 \text{ ADC (pulsed)}$$

$$I_B = -0.1 \text{ ADC (pulsed)}$$

$$\text{Pulse Width} = 300 \mu s$$

$$\text{Duty Cycle} = 1\%$$

6.2.6 (continued)

The collector-emitter saturation voltage shall be tested in accordance with Method 3071.1, MIL-STD 750A.

The unit shall be considered failed if the $V_{CE}(\text{sat})$ is greater than -0.45 VDC.

6.3 Electrical Intermediate

6.3.1 Forward-Current Transfer Ratio (h_{FE})

$$V_{CE} = -4 \text{ VDC}$$

$$I_C = -1 \text{ ADC (pulsed)}$$

$$\text{Pulse Width} = 300 \text{ } \mu\text{s}$$

$$\text{Duty Cycle} = 1\%$$

The forward current transfer ratio (h_{FE}) shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 30.

6.4 Environmental

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C, +0°C, -10°C, for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig \pm 10 psig, in a helium atmosphere for a minimum period of four hours. The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak rates in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 883D, Method 1014, Condition C, at a temperature of $125^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each device shall be tested in accordance with MIL-STD 202D, Method 204A, Condition C. The following shall apply.

1. Non-operating

6.4.6 (Continued)

2. Perform 2.4.2 Part 2 only

- (a) The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes

3. Paragraph 6.3, Electrical Intermediate, shall be run after completion of vibration testing.

6.5 Burn-In

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink whose temperature will be maintained at 70°C, +15°C, -5°C.

6.5.2 Test Conditions

The collector to emitter voltage V_{CE} shall be set at -10V. The collector current I_C shall be set at -1 ADC.

6.5.3 Test Length

The test shall be run for 168 hours, +12 hours, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed. Prior to the testing of Section 6.2, the transistor shall be allowed to return to ambient temperature (25°C).

6.6 Radiographic Examination

6.6.1 Procedure

The transistor shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 10X minimum magnification, and reject units having the following defects or characteristics:

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: Any unit displaying extraneous or foreign material that is not a normal portion of the product.
- c. Bonds and bond wires: any bond or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

TABLE 1

ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.0	Electrical	Para. 6.2
2.0	Environmental	Para. 6.4
2.1	High Temperature Storage	Para. 6.4.1
2.2	Electrical	Para. 6.3
2.3	Temperature Cycling	Para. 6.4.2
2.4	Electrical	Para. 6.3
2.5	Fine Leak	Para. 6.4.4
2.6	Gross Leak	Para. 6.4.5
2.7	Electrical	Para. 6.3
2.8	Vibration	Para. 6.4.6
2.9	Burn-In	Para. 6.5
2.10	Radiographic Examination	Para. 6.6

SCREENING SPECIFICATION
FOR
TRANSISTOR JAN2N3811

Document Number EPS-129

Prepared by
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SCREENING SPECIFICATION
FOR
TRANSISTOR 2N3811

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1.0

SCOPE

This document defines the necessary requirements for screening of Transistor 2N3811 to satisfy NASA High Reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0

APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 202D, Test Methods for Electronic and Electrical component parts

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 883, Test Methods and Procedures for Microelectronics

NHB 5300.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0

REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1

Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2 Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with NHB 5300.4(1A). Upon request, the subcontractor shall submit to Lockheed Electronics Co. (LEC) for approval, a listing of equipment and their intended usage.

3.3 Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration, shall be displayed on each item of this equipment.

3.4 Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD 202D.

4.2

Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table I.

4.3

Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted along with the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4

Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5

Serialization

All transistors shall be serialized in a manner that will be permanent during the testing period.

4.6

Reject Disposition

Each transistor that fails the inspections and tests of Table I shall be marked with a red dot and placed in a

4.6 (continued)

reject bag and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use 3M-401-5D paint for marking of parts.

4.7

Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed on the body at a point which will not interfere with reading the manufacturer's part number or date code identification. Use 3M-401-G3 paint for marking of parts.

4.8

Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9

Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with the device shipment. It shall verify that the transistors were processed in accordance with this specification and that all requirements have been met.

4.10

Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0

PREPARATION FOR DELIVERY

5.1

Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2

Packing for Shipment

The transistors packaged in accordance with Paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carriers rules and regulations applicable to the mode of transportation.

6.0

INSPECTION AND TEST METHODS

6.1

External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2

Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted. Both sections of the dual device shall be tested separately as defined in paragraphs 6.2 and 6.3.

6.2.1

Collector-Base Cutoff Current

$$V_{CB} = 50 \text{ VDC}$$

$$I_E = 0$$

The collector-base cutoff current shall be tested in accordance with Method 3036, Condition D, MIL-STD 750A.

The unit shall be considered failed if the I_{CBO} is greater than 0.01 μAdc .

6.2.2

Collector-Base Breakdown Voltage

$$I_C = 10 \text{ } \mu\text{Adc}$$

$$I_E = 0$$

The collector-base breakdown voltage shall be tested in accordance with Method 3001.1, Condition D, MIL-STD 750A.

6.2.3

The unit shall be considered failed if BV_{CBO} is less than 60 VDC.

6.2.3

Emitter-Base Breakdown Voltage

$$I_E = 10 \text{ } \mu\text{Adc}$$

$$I_C = 0$$

6.2.3 (continued)

The emitter-base breakdown voltage shall be tested in accordance with Method 3026.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{EBO} is less than 5.0 VDC.

6.2.4 Collector-Emitter Breakdown Voltage

$$I_C = 10 \text{ mAdc}$$

$$I_B = 0 \text{ (pulsed)}$$

$$\text{Pulse Width} = 300 \text{ } \mu\text{s}$$

$$\text{Duty Cycle} = 1\%$$

The collector-emitter breakdown voltage shall be tested in accordance with Method 3011.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{CEO} is less than 60 VDC.

6.2.5 Forward Current Transfer Ratio (H_{FE})

$$V_{CE} = 5.0 \text{ VDC}$$

$$I_C = 100 \text{ } \mu\text{Adc}$$

$$\text{Pulse Length} = 300 \text{ } \mu\text{s}$$

$$\text{Duty Cycle} = 1\%$$

The forward current transfer ratio shall be tested in accordance with Method 3076.1, MIL-STD 750A.

6.2.5 (continued)

The unit shall be considered failed if the h_{FE} is less than 300.

6.2.6 Base-Emitter Saturation Voltage

$$I_C = 100 \mu\text{Adc}$$

$$I_B = 10 \mu\text{Adc}$$

The base-emitter saturation voltage shall be tested in accordance with Method 3066.1, MIL-STD 750A.

The unit shall be considered failed if the $V_{BE}(\text{Sat})$ is greater than 0.7 VDC.

6.2.7 Collector-Emitter Saturation Voltage

$$I_C = 100 \mu\text{Adc}$$

$$I_B = 10 \mu\text{Adc}$$

The collector-emitter saturation voltage shall be tested in accordance with Method 3071.1, MIL-STD 750A.

The unit shall be considered failed if the $V_{CE}(\text{Sat})$ is greater than 0.2 VDC.

6.3 Electrical Intermediate

6.3.1 Forward Current Transfer Ratio (h_{FE})

$$V_{CE} = 5.0 \text{ VDC}$$

$$I_C = 100 \mu\text{Adc (pulsed)}$$

6.3.1 (continued)

Pulse Width = 300 μ s

Duty Cycle = 1%

The forward current transfer ratio (h_{FE}) shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 300.

6.4 Environmental

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C, +0°, -10°, for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five (5) cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig \pm 10 psig, in a helium atmosphere for a minimum period of four hours. The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak rates in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 883D, Method 1014, Condition C, at a temperature of $125^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each device shall be tested in accordance with MIL-STD-202D, Method 204A, Condition C. The following shall apply:

1. Non-operating
2. Perform 2.4.2 Part 2 only
 - (a) The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes

6.4.6 (continued)

3. Paragraph 6.3 Electrical Intermediate shall be run after Completion of Vibration Testing.

6.5 Burn-In

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink whose temperature will be maintained at 70°C, +15°C, -5°C.

6.5.2 Test Conditions

The collector to emitter voltage V_{CE} shall be set at 34 volts. The collector current I_C shall be set to 3 mAdc each portion.

6.5.3 Test Length

The test shall be run for 168 hours, +12 hours, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed. Prior to the testing of Section 6.2, the transistor shall be allowed to return to ambient temperature (25°C).

6.6 Radiographic Examination

6.6.1 Procedure

The transistors shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 100X minimum magnification, and reject units having the following defects or characteristics.

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: any unit displaying extraneous or foreign material that is not a normal portion of the product.
- c. Bonds and bond wires: any bonds or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

TABLE 1
ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.	Electrical.	Para. 6.2
2.	Environmental	Para. 6.4
2.1	High Temperature Storage.	Para. 6.4.1
2.2	Electrical.	Para. 6.3
2.3	Temperature Cycling	Para. 6.4.2
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2.10	Radiographic Examination.	Para. 6.6

SECTION 14

SCREENING SPECIFICATION
FOR
TRANSISTOR 2N4878

Document Number EPS-175

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

SCREENING SPECIFICATION
FOR
TRANSISTOR 2N4878

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1.0 SCOPE

This document defines the necessary requirements for the screening of Transistor 2N4878 to satisfy NASA high reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0 APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 202D, Test Methods for Electronic and Electrical Component Parts

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 883, Test Methods and Procedures for Microelectronics

NHB 5300.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0 REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1 Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2 Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with NHB 5300.4(1A). Upon request, the subcontractor shall submit

3.2 (continued)

to Lockheed Electronics Company (LEC) for approval, a listing of equipment and their intended usage.

3.3 Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration, shall be displayed on each item of this equipment.

3.4 Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0 RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1 General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD 202D.

4.2 Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table 1.

4.3 Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted with the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4 Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number, and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5 Serialization

All transistors shall be serialized in a manner that will be permanent during use and testing periods.

4.6 Reject Disposition

Each transistor that fails the inspections and tests of Table 1 shall be marked with a red dot and placed in a reject bag, and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use Minnesota Mining and Manufacturing Co.'s 3M-401-5D paint for marking of parts. Mixing and application should be done in accordance with manufacturer's specification sheet.

4.7 Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed on the body at a point which will not interfere with reading the manufacturer's part number or date code identification. Use Minnesota Mining and Manufacturing Co.'s 3M-401-G3 paint for marking of parts. Mixing and application should be done in accordance with manufacturer's specification sheet.

4.8 Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9 Certificate of Compliance

A certificate of compliance signed by the Quality Control Manager shall be included with the device shipment. It shall verify that the transistors were processed in accordance with this specification and that all requirements have been met.

4.10 Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0 PREPARATION FOR DELIVERY

5.1 Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2 Packaging for Shipment

The transistors packaged in accordance with Paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carrier's rules and regulations applicable to the mode of transportation.

6.0 INSPECTION AND TEST METHODS

6.1 External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2 Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted.

Note: All tests shall be performed on both transistors (dual package).

6.2.1 Collector Cutoff Current

$$V_{CB} = 45 \text{ VDC}$$

$$I_E = 0$$

The collector cutoff current shall be tested in accordance with Method 3036, Condition D, MIL-STD 750A.

The unit shall be considered failed if the I_{CB0} is greater than 0.1 nA dc.

6.2.2 Collector-Base Breakdown Voltage

$$I_C = 10 \text{ } \mu\text{A dc}$$

$$I_E = 0$$

The collector-base breakdown voltage shall be tested in accordance with Method 3001.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if BV_{CB0} is less than 60 VDC.

6.2.3 Emitter-Base Breakdown Voltage

$$I_E = 10 \text{ } \mu\text{A dc}$$

$$I_C = 0$$

The emitter-base breakdown voltage shall be tested in accordance with Method 3026.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{EB0} is less than 7.0 VDC.

6.2.4 Matching Characteristics

6.2.4.1 DC Current Gain Ratio

$$I_{C1} = 10 \mu A$$

$$I_{C2} = 10 \mu A$$

$$V_{CE1} = 5.0 V$$

$$V_{CE2} = 5.0 V$$

The forward current transfer ratio shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The DC Current Gain Ratio h_{FE1}/h_{FE2} shall have the following characteristics:

$$\text{Min} = 0.9 \quad \text{Max} = 1.0$$

Note: Lower of two h_{FE} is defined as h_{FE1} .

6.2.4.2 Base-Emitter Voltage Differential

$$I_{C1} = 10 \mu A$$

$$I_{C2} = 10 \mu A$$

$$V_{CE1} = 5.0 V$$

$$V_{CE2} = 5.0 V$$

The base-emitter voltage shall be tested in accordance with Method 3066.1, Test Condition B, MIL-STD 750A.

Base Emitter Voltage Differential $V_{BE1} - V_{BE2}$ shall be = 3.0 mV maximum.

6.2.5 Forward Current Gain (h_{FE})

$$V_{CE} = 5 \text{ VDC}$$

$$I_C = 10 \text{ } \mu\text{A dc}$$

The forward current gain shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 200.

6.2.6 Emitter Cutoff Current

$$I_C = 0$$

$$V_{EB} = 5.0 \text{ V}$$

The emitter cutoff current shall be tested in accordance with Method 3061.1, MIL-STD 750A.

The unit shall be considered failed if the I_{EB0} is greater than 0.1 nA.

6.2.7 Collector Saturation Voltage

$$I_C = 1.0 \text{ MA dc}$$

$$I_B = 0.1 \text{ MA dc}$$

The collector saturation voltage shall be tested in accordance with Method 3071.1, MIL-STD 750A.

6.2.7 (continued)

The unit shall be considered failed if the $V_{CE(sat)}$ is greater than 0.35 VDC.

6.3 Electrical Intermediate

Note: All tests shall be performed on both transistors (dual package).

6.3.1 Forward Current Gain (h_{FE})

$$V_{CE} = 5.0 \text{ VDC}$$

$$I_C = 10 \text{ } \mu\text{A dc}$$

The forward current gain (h_{FE}) shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 200.

6.4 Environmental

Note: All tests shall be performed on both transistors (dual package).

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C +0°C, -10°C, for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig \pm 10 psig, in a helium atmosphere for a minimum period of four hours. The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak ranges in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 883D, Method 1014, Condition C, at a temperature of $125^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each device shall be tested in accordance with MIL-STD-202D Method 204A Condition C. The following shall apply

1. Non-operating
2. Perform 2.4.2 Part 2 only
 - (a) The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes
3. Paragraph 6.3 Electrical Intermediate shall be run after completion of vibration testing.

6.5 Burn-In

Note: All tests shall be performed on both transistors (dual package).

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink. The transistor case temperature will be maintained at 70°C , $\pm 5^{\circ}\text{C}$.

6.5.2 Test Conditions

The collector to emitter voltage V_{CE} shall be set at 30 volts. The collector current I_C shall be set to 5 ma each collector.

6.5.3 Test Length

The test shall be run for 168 hours, +12 hours, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed. Prior to the testing of Section 6.2, the transistor shall be allowed to return to ambient temperature (25°C).

6.6 Radiographic Examination

Note: All tests shall be performed on both transistors (dual package).

6.6.1 Procedure

The transistor shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 100X minimum magnification, and reject units having the following defects or characteristics.

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: any unit displaying extraneous or foreign material that is not a normal portion of the product.

6.6.2 (Continued)

- c. Bonds and bond wires: any bond or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

Table 1

ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.0	Electrical	Para. 6.2
2.0	Environmental.	Para. 6.4
2.1	High Temperature Storage	Para. 6.4.1
2.2	Electrical	Para. 6.3
2.3	Temperature Cycling.	Para. 6.4.2
2.4	Electrical	Para. 6.3
2.5	Fine Leak.	Para. 6.4.4
2.6	Gross Leak	Para. 6.4.5
2.7	Electrical	Para. 6.3
2.8	Vibration.	Para. 6.4.6
2.9	Burn-In.	Para. 6.5
2.10	Radiographic Examination	Para. 6.6

SCREENING SPECIFICATION
FOR
TRANSISTOR SS3520

Document Number EPS-128

Prepared by
Lockheed Electronics Company
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Houston, Texas
Under Contract NAS 9-11373
for
National Aeronautics and Space Administration
Manned Spacecraft Center
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SCREENING SPECIFICATION
FOR
TRANSISTOR SS 3520

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1.0

SCOPE

This document defines the necessary requirements for the screening of transistor SS3520 to satisfy NASA high reliability requirements for the Electron-Proton Spectrometer (EPS).

2.0

APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of application shall form a part of this specification to the extent specified herein.

MIL-STD 202D, Test Methods for Electronic and Electrical component parts

MIL-STD 750A, Test Methods for Semiconductor Devices

MIL-STD 883, Test Methods and Procedures for Microelectronics

NHB 5300.4(1A), Reliability Program Provisions for Aeronautical and Space Systems Contractors

3.0

REQUIREMENTS FOR TEST LABORATORY SUBCONTRACTORS

3.1

Facilities

The subcontractor shall provide and maintain adequate facilities for inspecting and testing electronic components described in this specification.

3.2

Inspection, Measuring and Test Equipment

The subcontractor shall maintain and control inspection, measuring and test equipment in accordance with

3.2 (continued)

NHB 5300.4 (1A). Upon request, the subcontractor shall submit to Lockheed Electronics Company (LEC) for approval, a listing of equipment and their intended usage.

3.3 Calibration Records

The subcontractor shall prepare and have available for review by LEC, a written procedure and schedule for the maintenance and calibration of such equipment based on type, accuracy, purpose and degree of usage. Records of calibration shall be maintained and the calibration due date, or other identification attesting the due date of the next calibration, shall be displayed on each item of this equipment.

3.4 Calibration Traceability

Standards used for calibration shall be traceable to the National Bureau of Standards (NBS). No more than five steps shall be used to establish traceability from actual inspection and test equipment to the NBS.

4.0 RELIABILITY AND QUALITY ASSURANCE PROVISIONS

4.1 General

The procedures and methods of testing the transistors in accordance with this specification shall meet the general requirements of MIL-STD-202D.

4.2

Screening Inspections and Tests

Each transistor supplied shall be submitted in the sequence specified to the inspections and tests of Table 1.

4.3

Inspection and Test Data

A summary of the transistor data obtained during each inspection or test shall be prepared and submitted with the transistors to LEC. This summary shall list all transistors that failed electrical tests and the number that failed each parameter. The raw test data shall also be delivered to LEC with the transistors.

4.4

Inspection and Test Records

Inspection and test records shall include part number, serial number, inspection or test number, number of defects found, kinds of defects, acceptance number and the disposition inspector's identity. Records of all inspections and tests shall be delivered to LEC along with the transistors.

4.5

Serialization

All transistors shall be serialized in a manner that will be permanent during use and testing periods.

4.6

Reject Disposition

Each transistor that fails the inspections and tests of Table 1 shall be marked with a red dot and placed in a reject bag, and tagged to note unit part number, serial number and inspection or test failed. These units shall also be delivered to LEC. Use 3M-401-5D paint for marking of parts.

4.7

Marking of Acceptable Parts

Transistors which meet the requirements of this specification shall be identified with a permanent green dot placed on the body of the transistor. The dot shall be placed on the body at a point which will not interfere with reading the manufacturers part number or date code identification. Use 3M-401-G3 paint for marking of parts.

4.8

Acceptance

Preliminary inspection for compliance with the requirements of this specification may be performed at origin by an authorized representative of the Government. Final acceptance for the Contracting Officer shall be performed by the assigned project engineer.

4.9

Certificate of Compliance

A certificate of compliance signed by the Quality Control manager shall be included with the device shipment. It shall verify that the transistors

4.9 (continued)

were processed in accordance with this specification and that all requirements have been met.

4.10 Notification of Government Source Inspector

The Government Representative who has been delegated quality assurance function at your test facility shall be notified immediately upon receipt of this order.

5.0 PREPARATION FOR DELIVERY

5.1 Type of Packaging

Each transistor shall be packaged in a suitable container which will protect the body and leads of the device during shipment. The rejected parts shall be identified and packaged separately from the acceptable items.

5.2 Packaging for Shipment

The transistors packaged in accordance with paragraph 5.1 shall be packed to afford protection against damage during direct shipment from the test laboratory to the receiving activity. Containers will comply with the carrier's rules and regulations applicable to the mode of transportation.

6.0 INSPECTION AND TEST METHODS

6.1 External Visual

The transistors shall be examined to verify that the materials, design, construction, marking and workmanship are in accordance with the applicable requirements.

6.2 Electrical

All electrical tests shall be performed at an ambient temperature of 25°C unless otherwise noted.

6.2.1 Collector-Base Cutoff Current

$$V_{CB} = 15 \text{ VDC}$$

$$I_E = 0$$

The collector-base cutoff current shall be tested in accordance with Method 3036, Condition D, MIL-STD 750A.

6.2.1.5 The unit shall be considered failed if the I_{CBO} is greater than 10 nA dc.

6.2.2 Collector - Base Breakdown Voltage

$$I_C = 1.0 \text{ } \mu\text{A dc}$$

6.2.2 (continued)

$$I_E = 0$$

The collector - base breakdown voltage shall be tested in accordance with Method 3001.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if BV_{CBO} is less than 35 VDC.

6.2.3 Emitter - Base Breakdown Voltage

$$I_E = 10 \mu A \text{ dc}$$

$$I_C = 0$$

The emitter - base breakdown voltage shall be tested in accordance with Method 3026.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{EBO} is less than 3.0 VDC.

6.2.4 Collector - Emitter Breakdown Voltage

$$I_C = 3.0 \text{ mA dc (pulsed)}$$

$$I_B = 0$$

$$\text{Pulse width} \leq 300 \mu s$$

$$\text{Duty Cycle} = 1\%$$

6.2.4 (continued)

The collector - emitter breakdown voltage shall be tested in accordance with Method 3011.1, Condition D, MIL-STD 750A.

The unit shall be considered failed if the BV_{CEO} is less than 20 VDC.

6.2.5 Forward Current Ratio (h_{fe})

$$V_{CE} = 15 \text{ VDC}$$

$$I_C = 2.0 \text{ mA dc}$$

$$f = 1.0 \text{ kHz}$$

The forward transfer ratio shall be tested in accordance with Method 3206, MIL-STD 750A.

The unit shall be considered failed if the h_{fe} is less than 100.

6.2.6 Base - Emitter Saturation Voltage

$$I_C = 10 \text{ mA dc}$$

$$I_B = 1.0 \text{ mA dc}$$

The base-emitter saturation voltage shall be tested in accordance with Method 3066.1, MIL-STD 750A.

6.2.6 (continued)

The unit shall be considered failed if the $V_{BE}(\text{Sat})$ is greater than 1.0 VDC.

6.2.7 Collector - Emitter Saturation Voltage

$$I_C = 10 \text{ mA dc}$$

$$I_B = 1.0 \text{ mA dc}$$

The collector - emitter saturation voltage shall be tested in accordance with Method 3071.1, MIL-STD 750A.

The unit shall be considered failed if the $V_{CE}(\text{Sat})$ is greater than 0.4 VDC.

6.2.8 Unity Gain Frequency

$$V_{CE} = 15 \text{ VDC}$$

$$I_C = 1 \text{ mA}$$

$$f = 100 \text{ MHz}$$

The Unity Gain (f_t) shall be tested in accordance with Method 3261, Use, Method 3306.1, Condition A to determine the magnitude of the common emitter small-signal short-circuit transfer ratio. The unit shall be considered failed if the f_t is less than 500 MHz.

6.3 Electrical Intermediate

6.3.1 Forward - Current Transfer Ratio (h_{FE})

$$V_{CE} = 2.0 \text{ VDC}$$

$$I_C = 2.0 \text{ mA dc (pulsed)}$$

$$\text{Pulse Width} = 300 \text{ } \mu\text{s}$$

6.3.1 (continued)

Duty Cycle = 1%.

The forward current transfer ratio (h_{FE}) shall be tested in accordance with Method 3076.1, MIL-STD 750A.

The unit shall be considered failed if the h_{FE} is less than 75.

6.4 Environmental

6.4.1 High Temperature Storage

The transistor shall be exposed to a temperature of 200°C, +0°C, -10°C, for a period of 48 hours, +24 hours, -0 hours.

6.4.2 Temperature Cycling

The transistor shall be tested in accordance with MIL-STD 202D, Method 102, Condition C. The transistor shall be subjected to five cycles performed continuously.

6.4.3 Acceleration

The transistor shall be tested in accordance with MIL-STD 750A, Method 2006. The transistor shall be accelerated for one minute in the Y_1 plane at a level of 20,000 g's.

6.4.4 Fine Leak

The transistor shall be tested in accordance with MIL-STD 202D, Method 112, Condition C. The units shall be subjected to a pressure of 60 psig, \pm 10 psig, in a helium atmosphere for a minimum period of four hours.

6.4.4 (continued)

The units shall then be placed in a mass spectrometer to measure helium leakage. Units exhibiting leak rates in excess of 10^{-8} atm-cc/sec shall be considered failed.

6.4.5 Gross Leak

The transistor shall be tested in accordance with MIL-STD 883D, Method 1014, Condition C, at a temperature of $125^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The unit shall be submerged to a minimum of one inch into the hot liquid and observed for a minimum of one minute. Any unit emitting a continuous stream of bubbles shall be considered failed.

6.4.6 Vibration

Each transistor shall be tested in accordance with MIL-STD 202D, Method 204A, Cond. C. The following shall apply:

1. Non-operating
2. Perform 2.4.2 part 2 only. The entire frequency range of 55 to 2000 cycles (no return sweep) shall be traversed in 10 ± 3 minutes.
3. Paragraph 6.3, Electrical Intermediate, shall be run after completion of vibration testing.

6.5 Burn-In

6.5.1 Heat Sink

The transistor shall be mounted on a heat sink whose temperature will be maintained at 70°C , $+15^{\circ}\text{C}$, -5°C .

6.5.2 Test Conditions

The collector to emitter voltage V_{CE} shall be set at 10 volts. The collector current I_C shall be set to 15 mA dc.

6.5.3 Test Length

The test shall be run for 168 hours, +12, -0 hours. Section 6.2 of this specification shall be rerun, and any transistor failing any portion of Section 6.2 shall be considered failed. Prior to the testing of Section 6.2, the transistor shall be allowed to return to ambient temperature (25°C).

6.6 Radiographic Examination

6.6.1 Procedure

The transistor shall be X-rayed in two mutually perpendicular planes. Maintain unit identity between units and film position.

6.6.2 Acceptance

Examine film, using 100X minimum magnification, and reject units having the following defects or characteristics:

- a. Poor chip mounting: any unit displaying less than 50% contact between chip and mounting base.
- b. Extraneous material: any unit displaying extraneous or foreign material that is not a normal portion of the product.

6.6.2 (continued)

- c. Bonds and bond wires: any bond or bond wires that are misplaced, loose or extra. Bond wires that are within 0.005 inch of any area not electrically common with the bond wire.
- d. Miscellaneous: any anomaly which, in the opinion of the inspector, will degrade performance or reliability of the unit.

TABLE I
ELECTRICAL AND ENVIRONMENTAL REQUIREMENTS

1.	Electrical	Para. 6.2
2.	Environmental	Para. 6.4
2.1	High Temperature Storage	Para. 6.4.1
2.2	Electrical	Para. 6.3
2.3	Temperature Cycling	Para. 6.4.2
2.4	Electrical	Para. 6.3
2.5	Fine Leak	Para. 6.4.4
2.6	Gross Leak	Para. 6.4.5
2.7	Electrical	Para. 6.3
2.8	Vibration	Para. 6.4.6
2.9	Burn-In	Para. 6.5
2.10	Radiographic Examination	Para. 6.6

3.3.10.2 Restriction on Use of Transistors and Capacitors.

None of the restricted parts are used in the EPS.

3.3.10.3 Soldering NBH5300.4(3A)

The soldering techniques and requirements are imposed by the Quality Assurance Plan, Reliability Plan and Inspection during assembly. The requirements of NBH5300.4(3A) are by definition and implementation rather than by analysis.

3.3.10.4 Welding and Brazing

The welded techniques and requirements are imposed by the Quality Assurance Plan, Reliability Plan and Inspection during assembly. The requirements of MIL-W-6858 are by definition and implementation rather than by analysis.

3.3.10.7 Adhesive Bonding

The adhesive was selected on the basis of satisfactory performance in prior applications. The only area using adhesive is the strip heaters. All operations connected with bonding, were conducted in a dust free area. Specific materials are described in the fabrication procedures. Bonding was accomplished according to manufacturer's recommended procedures. The specification used in this process is MIL-A-9067C.

3.3.10.9 Parts and Material Selection.

Refer to paragraph 3.3.9

3.3.10.9.1 Controlled Electrical, Electronic and Electro-mechanical (EEE) Parts

See EEE Parts List attached.

ELECTRON-PROTON SPECTROMETER
EEE PARTS LIST

LEC Document Number EPS-469

Prepared by
Lockheed Electronics Company
Houston Aerospace Systems Division
Houston, Texas

Under Contract NAS 9-11373

for the
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

June, 1971

EEE PARTS LIST

Prepared by:

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Houston, Texas

ELECTRON-PROTON SPECTROMETER

The Electron-Proton Spectrometer EEE Parts List catalogs the electrical, electronic, and electromechanical (EEE) parts used in the EPS. The list is divided into sections each representing a particular assembly. The parts of each assembly are grouped by their generic name. Parts are identified by size, rating, material, and part numbers as applicable. Drawing designation, manufacture, specification number, method of qualification, qualification status, and number required are also shown.

Parts used on the EPS are procured to user's specifications that include reliability and quality assurance for each application. Electronic parts have been derated to obtain the best operating levels for prolonged reliability.

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
SEC39107185-301											

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS											
R1		RESISTOR - Selected Metal	Mepco	RNC50	MIL-R-55182	Established Reliability	Q	1										5
R2		RESISTOR - 7.87k Ω , 1%, 1/20W, Film Metal	Mepco	K7871FR	MIL-R-55182	Established Reliability	Q	1										5
R3		RESISTOR - 7.15k Ω , 1%, 1/20W, Film Metal	"	RNC50 K7151FR	"	Established Reliability	Q	1										5
R4		RESISTOR - 255 Ω , 1%, 1/20W, Film Metal	"	RNC55 K2550FR	"	Established Reliability	Q	1										5
R5		RESISTOR - 604 Ω , 1%, 1/20W, Film Metal	"	RNC50 K6040FR	"	Established Reliability	Q	1										5
R6		RESISTOR - 1.21k Ω , 1%, 1/20W, Film Metal	"	RNC50 K1211FR	"	Established Reliability	Q	1										5
R7		RESISTOR - 100M Ω , 5%	Caddock	1712- 100 Meg.	"	LEC Spec #168	Q	1										5
R8		RESISTOR - 2.55k Ω , 1%, 1/20W, Film Metal	Mepco	RNC55 K2551FR	"	Established Reliability	Q	1										5
R9		RESISTOR - 93.1 Ω , 1%, 1/10W, Film Metal	"	RNC50 K93R1FR	"	Established Reliability	Q	1										5
R10		RESISTOR - 49.9 Ω , 1%, 1/10W, Film Metal	"	RNC55 K49R9FR	"	Established Reliability	Q	1										5
R11, R16		RESISTOR - 49.9k Ω , 1%, 1/20W, Film Metal	"	RNC50H 4991FS	"	Established Reliability	Q	2										10
R12		RESISTOR - 4.99k Ω , 1%, 1/20W, Film Metal	"	RNC50H 4991FS	"	Established Reliability	Q	1										5
R13		RESISTOR - Selected Metal	Caddock		"	LEC Spec #168	Q	1										5
R14, R21		RESISTOR - 2.67k Ω , 1%, 1/20W, Film Metal	MEPCO	RNC50H 2671FS	"	Established Reliability	Q	2										10
R15, R20		RESISTOR - 80.6k Ω , 1%, 1/20, Film Metal	"	RNC50H 8062FS	"	Established Reliability	Q	2										10
R17		POTENTIOMETER - 500 Ω	Bourne	3260W 1-501	MIL-R-27208	LEC Spec #124	Q	1										5

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NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
SEC39107185-301											

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	R18, R19	RESISTOR - 30.1Ω, 1%, 1/20W, Film	Mepco	RNC50H 30R1FS	MIL-R-55182	Established Reliability	Q	1											5
	C1	CAPACITOR-Variable, .6-1.8pF, 750V	JFD	RVC-12	LEC Spec EPS-232	Screen and Burn-in	Q	1											5
	C2	CAPACITOR - NPO, 1.0pF, 25%, 50V	USCC	RC33C1ROD	MIL-C-39003	Screen and Burn-in	Q	1											5
	C3	CAPACITOR -47μF, 10%, 6V, Tantalum	Kemet	T210B476 K00GRS	MIL-C-39003	Established Reliability	Q	1											5
	C4	CAPACITOR-3.3μF, 10%, 15V, Tantalum	Kemet	T210A335 K015RS	"	Established Reliability	Q	1											5
	C5, C6, C8	CAPACITOR - .01μF, 10%, 200V, ceramic	Kemet	CKR06BX 103KR	"	Established Reliability	Q	3											15
	C7, C9	CAPACITOR - 15μF, 10%	Kemet	T210B156 K020RS	"	Established Reliability	Q	2											10
	C10	CAPACITOR - .01μF, 10%	Kemet	CKR06BX 103MR	"	Established Reliability	Q	1											5
	C11	CAPACITOR - 100pF, 10%	Kemet	CKP05BX 101KR	"	Established Reliability	Q	1											5
	Q1	TRANSISTOR - FET	Texas Instrument	(JANTX-2N4858) Selected SSC6113	MIL-S-19500/385	Established Reliability	Q	1											5
	Q2, Q4	TRANSISTOR - PNP, Fast Switching, Silicon	Motorola	JAN-TX 2N-3251A	MIL-S-19500/323	Established Reliability	Q	2											10
	Q3	TRANSISTOR - NPN, Low Power, Silicon	Motorola	JANTX 2N-2708	MIL-S-19500/302	Hi-Rel Testing	Q	1											5
	CR1	DIODE - General Purpose, Silicon	Texas Instrument	JANTX 1N649	MIL-S-19500/240	Established Reliability	Q	1											5
	CR2, CR3	DIODE - Silicon	Dickson	1N4567A	Dickson Hi-Rel Spec.	Hi-Rel Testing	Q	2											10

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
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NEXT ASSEMBLY: NUMBER SEC39107196
NAME PREAMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107185
NAME PREAMPLIFIER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107185-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	L1, L2, L4	INDUCTOR - 100μH	J. W. Miller	9210-76	MIL-C-15305	Hi-Rel Testing	Q	3											15
	L3	INDUCTOR - 20mH	Collins	526-2930- 130	MIL-C-15305	Established Reliability	Q	1											5
		CONNECTOR - Screw Mount	Microdot	MCDM1- 15P4L4-0.5	MIL-C-38300A	Microdot Hi-Rel Tests MIL-STD-202D	Q	1											5
		CONNECTOR - Receptacle	Microdot	031-0070- .001	MIL-C-38300A	Microdot Hi-Rel Tests MIL-STD-202D	Q	1											5

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SKYLAB ELECTRON-PROTON SPECTROMETER

EEE PARTS LIST REVISION A (UPDATE)

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER _____
 NAME _____

ASSEMBLY:
 NUMBER SEC39107185-303
 NAME DETECTOR LEAKAGE MONITOR

QUANTITY PER SUB ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	FROM -301 to -303	FROM -302 to -303								
	CR2	DIODE - 6.4V. Update: Part Deleted		1N4567A	MIL-S-19500	High-Rel Component	Q		1	1								
	CR3	DIODE - 6.4V. Update: Part Deleted		1N4567A	MIL-S-19500	High-Rel Component	Q		1	1								
	R14, R21	RESISTOR - 2.67k, 1% Update: Parts Deleted	Mepco	RNC50H 2671FR	MIL-R-55182	Established Reliability	Q		2	2								
	R18	RESISTOR - 30.1Ω, 1% Update: Part Deleted	Mepco	RNC50H 30R1FR	MIL-R-55182	Established Reliability	Q		1	1								
	R19	RESISTOR - 30.1Ω, 1% Update: Replaced with .020 Dumet Lead	Mepco	RNC50H 30R1FR	MIL-R-55182	Established Reliability	Q		1	1								
	R15, R20	RESISTOR - 80.6k, 1% Update: Part Deleted	Mepco	RNC50H 8062FR	MIL-R-55182	Established Reliability	Q		2	2								
	R11	RESISTOR - 49.9k, 1% Changed to 100k, 1%	Mepco Mepco	RNC50H 4992FR RNC50H 1003FR	MIL-R-55182 MIL-R-55182	Established Reliability Established Reliability	Q Q		1	1								
	R16	RESISTOR - 49.9k, 1% Changed to 69.8k, 1%	Mepco Mepco	RNC50H 4992FR RNC50H 6982FR	MIL-R-55182 MIL-R-55182	Established Reliability Established Reliability	Q Q		1	1								

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SKYLAB ELECTRON-PROTON SPECTROMETER

EEE PARTS LIST REVISION A (UPDATE)

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER _____
 NAME _____

ASSEMBLY: NUMBER SEC39107185-303
 NAME DETECTOR LEAKAGE MONITOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	FROM -301 to -303	FROM -302 to 303									

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS												
	R13	RESISTOR - 5 Meg, 18 Changed to 100k	Caddock	MK132	MIL-R-55182	Hi-Rel Testing	Q												
			Caddock	MK100k	MIL-R-55182	Hi-Rel Testing	Q	1											

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39107190
NAME PREAMPLIFIER SLICE

ASSEMBLY :
NUMBER SEC39107184
NAME DETECTOR BIAS-SUPPLY

[illegible]

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39107184
 NAME DETECTOR BIAS SUPPLY

ASSEMBLY:
 NUMBER SEC39106694
 NAME DETECTOR RECTIFIER & FILTER

QUANTITY PER SUB ASSEMBLY

SUB
ASSEMBLY
NUMBER

SEC39106694-301

TOTAL REQUIRED
PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	R8	RESISTOR - 50k Ω , 1%, 3/4W	Caddock	MK-132-50K	MIL-R-55182	Hi-Rel Testing	Q	1										1
	R9, R11, R12	RESISTOR - 10M Ω , 1%, 1/2W	Caddock	MG660-10MEG	"	Hi-Rel Testing	Q	3										3
	R10	RESISTOR - 100k Ω , 1%, 3/4W	Caddock	MK-132-100K	"	Hi-Rel Testing	Q	1										1
	C4 - C7	CAPACITOR - .01 μ f, 1000V	Erie	828-1KV+ X5T-103M	MIL-C-39014	Hi-Rel Testing	Q	4										4
	C8	CAPACITOR - 1000pf, 200V	Kemet	CKR05BX 102KP	MIL-C-39014	Established Reliability	Q	1										1
	CR3 - CR8	DIODE	Texas Instruments	JAN-TX-1N649	MIL-S-19500	Established Reliability	Q	6										6

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106670
NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
NUMBER SEC39107187
NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	SEC39107187-301	SEC39107187-302								
	R1	POTENTIOMETER - 10k Ω , 5%	Bourns	3260HM 39103	MIL-R-27208	Hi-Rel Testing	Q	1	1									5
	R2	RESISTOR - 44.2k Ω , 1%, 3/4W	Caddock	MK132	MIL-R-55182	Hi-Rel Testing	Q	1	1									5
	R2	RESISTOR - 140k Ω , 1%, 3/4W	Caddock	MK132	"	Hi-Rel Testing	Q		1									1
	R3	RESISTOR - 165 Ω , 1%, 1/20W	Mepco	RNC50H 1650FR	"	Established Reliability	Q	1	1									5
	R4, R28	RESISTOR - 324 Ω , 1%, 1/20W	"	RNC50H 3240FR	"		Q	2	2									10
	R4, R28	RESISTOR - 267 Ω , 1%, 1/20W	"	RNC50H 2670FR	"		Q	2	2									10
	R4, R28	RESISTOR - 169 Ω , 1%, 1/20W	"	RNC50H 1690FR	"		Q		2									2
	R5, R8 R29, R33	RESISTOR - 78.7k Ω , 1%, 1/20W	"	RNC50H 7872FR	"		Q	4	4									20
	R6, R30	RESISTOR - 80.6k Ω , 1%, 1/20W	"	RNC50H 8062FR	"		Q	2	2									10
	R7, R31	RESISTOR - 59k Ω , 1%, 1/20W	"	RNC50H 5902FR	"		Q	2	2									10
	R9, R32	RESISTOR - 4.87k Ω , 1%, 1/20W	"	RNC50H 4871FR	"		Q	2	2									10
	R10, R11 R34, R35	RESISTOR - 2.43k Ω , 1%, 1/20W	"	RNC50H 2431FR	"	Established Reliability	Q	4	4									20

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106670
 NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
 NUMBER SEC39107187
 NAME PULSE AMPLIFIER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107187-301	SEC39107187-302									

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS											
	R12, R36	RESISTOR - 2.74k Ω , 1%, 1/20W	Mepco	RNC50H 2741FR	MIL-R-55182	Established Reliability	Q	2	2									10
	R13, R37	RESISTOR - 3.74k Ω , 1%, 1/20W	"	RNC50H 3741FR	"		Q	2	2									10
	R14, R15 R38, R39	RESISTOR - 25.5k Ω , 1%, 1/20W	"	RNC50H 2552FR	"		Q	4	4									20
	R16, R40	RESISTOR - 8.25k Ω , 1%, 1/20W	"	RNC50H 8252FR	"		Q	2	2									10
	R17, R41	RESISTOR - 1.13k Ω , 1%, 1/20W	"	RNC50H 1132FR	"		Q	2	2									10
	R18, R19 R42, R43	RESISTOR - 43.2 Ω , 1%, 1/20W	"	RNC50K 43R2FR	"		Q	4	4									20
	R20, R44	RESISTOR - 200 Ω , 1%, 1/20W	"	RNC50H 2000FR	"		Q	2	2									10
	R21, R24 R45, R51	RESISTOR - 10 Ω , 1%, 1/20W	"	RNC50K 10R0FR	"		Q	4	4									20
	R22, R23, R47, R49	RESISTOR - 40.2 Ω , 1%, 1/20W	"	RNC50K 40R2FR	"		Q	4	4									20
	R25, R26 R46, R52	RESISTOR - 32.4 Ω , 1%, 1/20W	"	RNC50K 32R4FR	"		Q	4	4									20
	R27	RESISTOR - 215 Ω , 1%, 1/20W	"	RNC50H 2150FR	"	Established Reliability	Q	1	1									5

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425NAME ELECTRON-PROTON SPECTROMETERNEXT ASSEMBLY: NUMBER SEC39106670NAME PULSE AMPLIFIER SLICE

ASSEMBLY:

NUMBER SLC39107187NAME PULSE AMPLIFIER

QUANTITY PER SUB ASSEMBLY

SUB
ASSEMBLY
NUMBER

SLC39107187-301

SLC39107187-302

TOTAL REQUIRED
PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	R40	RESISTOR - 49.9Ω, 1%, 1/20W	Mepco	RNC50K 49R9FR	MIL-R-55182	Established Reliability	Q	1	1									5
	R50	RESISTOR - 100Ω, 1%, 1/20W	"	RNC50H 1000FR	"	Established Reliability	Q	1	1									5
	C1, C16	CAPACITOR - 850pf, 50V	USCC	RC37C 851F	MIL-C-39014	Hi-Rel Testing	Q	2										8
	C1, C16	CAPACITOR - 51pf, 50V	"	RC37C 516F	"	Hi-Rel Testing	Q		2									2
	C2, C17	CAPACITOR - .18μf, 50V	Kemet	T2100A 184K050RS	MIL-C-39003	Established Reliability	Q	2	2									10
	C3, C7, C13, C18, C24, C28, C31, C32	CAPACITOR - .01μf, 200V	Kemet	CKR06BX 103KP	MIL-C-39014	Established Reliability	Q	8	8									40
	C4, C19	CAPACITOR - 5.0pf, 50V	USCC	RC37C5 ROD	MIL-C-39014	Hi-Rel Test Qual.	Q	2										8
	C4, C19	CAPACITOR - 2.2pf, 50V	"	RC12C2 R2D	"	↑ ↓	Q		2									2
	C5, C20	CAPACITOR - 22pf, 50V	"	RC37C 220J	"		Q		2									8
	C5, C20	CAPACITOR - 10pf, 50V	"	RC37C 100J	"	Hi-Rel Test Qual.	Q		2									8
	C6, C9, C22, C23	CAPACITOR - 3.3μf, 200V	Kemet	T210A335-K015RS	MIL-C-39003	Established Reliability	Q	4	4									20
	C8, C21	CAPACITOR - .033μf, 100V	"	CKR06BX 333KP	MIL-C-39014	Established Reliability	Q	2	2									10
	C10, C11, C25, C26	CAPACITOR - 150pf, 50V	USCC	RC37151F	MIL-C-39014	Hi-Rel Test Qual.	Q		4									16

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
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 NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
 NUMBER SEC39107187
 NAME PULSE AMPLIFIER

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	SEC39107187-301	SEC39107187-302								
	C10, C11 C25, C26	CAPACITOR - 91pf, 50V	USCC	RC37C910P	MIL-C-39014	Hi-Rel Test Qual	Q	4										4
	C12, C27	CAPACITOR - 3.3pf, 50V	"	RC12C3R3D	"		Q	2										8
	C12, C27	CAPACITOR - 3.9pf, 50V	"	RC12C3R9D	"		Q	2										8
	C12, C27	CAPACITOR - 1.5pf, 50V	"	RC12C1R5D	"		Q	2										2
	C12, C27	CAPACITOR - 2.7pf, 50V	"	RC12C2R7D	"		Q	2										8
	C12, C27	CAPACITOR - 1.0pf, 50V	"	RC12C1R0D	"		Q	2										2
	C14, C29	CAPACITOR - 68pf, 50V	"	RC37C680J	"		Q	2										8
	C14, C29	CAPACITOR - 27pf, 50V	"	RC37C270J	"		Q	2										2
	C15, C30	CAPACITOR - 180pf	USCC	RC37C181J			Q	2	2									10
	C15, C30	CAPACITOR - 68pf	"	RC37C680J	"		Q	2										2
	C15, C30	CAPACITOR - 100pf.	"	RC37C101J	"	Hi-Rel Test Qual	Q	2										2

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106670
 NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
 NUMBER SEC39107187
 NAME PULSE AMPLIFIER

QUANTITY PER SUB ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	SUB ASSEMBLY NUMBER										TOTAL REQUIRED PER ASSEMBLY
								SEC39107187-301	SEC39107187-302									
	Q1 Thru Q4	TRANSISTOR - Dual	Intersil	2N4878	MIL-S-19500	LEC Hi-Rel Test Qual	Q	4	4									20
	Q5 Thru Q8	TRANSISTOR	Motorola	SS2638H (2N4261)	MIL-S-19500	Motorola MIL-STD-883	Q	4	4									20
	Q9 Thru Q12	TRANSISTOR	Motorola	SS3520 (2N2708)	MIL-S-19500	Motorola Hi-Rel Tests	Q	4	4									20
	CR1 Thru CR18	DIODE	Texas Instruments	JANTX-1N4153	MIL-S-19500	Established Reliability	Q	18	18									90
	P1	CONNECTOR	Microdot	MCDMI-15P-4L4-0.5	MIL-C-38300A	Hi-Rel Test Qual	Q	1	1									5
	S1	CONNECTOR	Microdot	MCDMI-15S-4L40.5	MIL-C-388300	Hi-Rel Test Qual	Q	1	1									5

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106670
 NAME PULSE AMPLIFIER SLICE

ASSEMBLY:
 NUMBER SEC39107189
 NAME TEMPERATURE MONITOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107189-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS												
	R1	RESISTOR - Selected Value	Caddock	MK132 Selected	MIL-R-55182	Hi-Rel Test Qual	Q	1											1
	R2, R9	RESISTOR - 392Ω, 1%, 1/20W	Mepco	RNC50H 3920FR	"	Established Reliability	Q	2											2
	R3, R10	POTENTIOMETER - 50Ω	Bourns	3260WM 39500	MIL-R-22097	Hi-Rel Testing	Q	2											2
	R4, R11	RESISTOR - Selected Value	Mepco	RNC55H4 Selected	MIL-R-55182	Established Reliability	Q	2											2
	R5, R12	RESISTOR - 549Ω, 1%, 1/20W	"	RNC50H 5490FR	"	Established Reliability	Q	2											2
	R6, R13	POTENTIOMETER - 500Ω	Bourns	3260WM 39501	MIL-R-22097	Hi-Rel Testing	Q	2											2
	R7, R14	RESISTOR - 13.7kΩ, 1%, 1/2-W	Mepco	RNC50H 1372FR	MIL-R-55182	Established Reliability	Q	2											2
	R8	RESISTOR - Selected Value	Mepco	RNC50H Selected	"	Established Reliability	Q	1											1
	VR1	DIODE - Zener (1N4901A)	Dickson	DT710415D	MIL-S-19500	Hi-Rel Testing	Q	1											1
	VR2	DIODE - Zener (1N4567A)	Dickson	DT710415C	MIL-S-19500	Hi-Rel Testing	Q	1											1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC391066425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305						
	R1, R12	RESISTOR - 4.53k Ω , 1 $\%$, 1/20W	Mepco	RNC50H 4531FR	MIL-R-55182	Established Reliability	Q	2	2	2	2	2						10
	R2, R13	RESISTOR - 3160 Ω , 1 $\%$, 1/20W	"	RNC50H 3161FR	"	↑	Q	2	2	2	2	2						10
	R3	RESISTOR - 1540 Ω , 1 $\%$, 1/20W	"	RNC50H 1541FR	"		Q	1			1	1						3
	R3	RESISTOR - 1470 Ω , 1 $\%$, 1/20W	"	RNC50H 1471FR	"	↓	Q		1									1
	R3	RESISTOR - 1500 Ω , 1 $\%$, 1/20W	"	RNC50H 1501FR	"	Established Reliability	Q			1								1
	R4	RESISTOR - 580k Ω , 1 $\%$, 3/4W	Caddock	MK132	"	Hi-Rel Testing	Q	1										1
	R4	RESISTOR - 550k Ω , 1 $\%$, 3/4W	"		"	Hi-Rel Testing	Q		1									1
	R4	RESISTOR - 480k Ω , 1 $\%$, 3/4W	"		"	Hi-Rel Testing	Q			1								1
	R4	RESISTOR - 440k Ω , 1 $\%$, 3/4W	"		"	Hi-Rel Testing	Q				1							1
	R4	RESISTOR - 500k Ω , 1 $\%$, 3/4W	"	MK132	"	Hi-Rel Testing	Q					1						1
	R5 (1)	RESISTOR - 750 Ω , 1 $\%$, 1/20W	Mepco	RNC50H 7500FR	"	Established Reliability	Q					1						1
	R5 (2)	RESISTOR - 715 Ω , 1 $\%$, 1/20W	"	RNC50H 7150FR	"	↑	Q					1						1
	R5 (3)	RESISTOR - 787 Ω , 1 $\%$, 1/20W	"	RNC50H 7870FR	"		Q				1							1
	R5 (4)	RESISTOR - 1k Ω , 1 $\%$, 1/20W	"	RNC50H 1001FR	"	↓	Q		1									1
	R5 (5)	RESISTOR - 1.13k Ω , 1 $\%$, 1/20W	"	RNC50H 1131FR	"	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY					TOTAL REQUIRED PER ASSEMBLY
	SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305	

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS											TOTAL REQUIRED PER ASSEMBLY
	R6	POTENTIOMETER - 100Ω, 5%	Bourns	3260HM 39101	MIL-R-22097	Hi-Rel Testing	Q	1										1
	R6	POTENTIOMETER - 5%, 200Ω	"	3260HM 39201	MIL-R-22097	Hi-Rel Testing	Q		1	1	1	1						4
	R7 (1)	RESISTOR - 464Ω, 1%, 1/20W	Mepco	RNC50H 4640FR	MIL-R-55182	Established Reliability	Q						1					1
	R7 (2)	RESISTOR - 604Ω, 1%, 1/20W	"	RNC50H 6040FR	"	↑	Q					1						1
	R7 (3)	RESISTOR - 487Ω, 1%, 1/20W	"	RNC50H 2940FR	"		Q					1						1
	R7 (4)	RESISTOR - 267Ω, 1%, 1/20W	"	RNC50H 2670FR	"		Q	1										1
	R7.	RESISTOR - 294Ω, 1%, 1/20W	"	RNC50H 2940FR	"	↓	Q		1									1
	R8	RESISTOR - 2.10kΩ, 1%, 1/20W	"	RNC50H 2101FR	MIL-R-55182	Established Reliability	Q		1									1
	R8	RESISTOR - 1.69kΩ, 1%, 1/20W	"	RNC50H 1691FR	"	Established Reliability	Q		1	1	1	1						4
	R9	POTENTIOMETER - 200Ω, 5%	Bourns	3260HM 39201	MIL-R-22097	Hi-Rel Testing		1										1
	R9	POTENTIOMETER - 50Ω, 5%	"	3260HM 39500	MIL-R-22097	Hi-Rel Testing	Q		1	1	1	1						4
	R10, R25	RESISTOR - 000Ω, Shorting Wire						2	2	2	2	2						10
	R11	RESISTOR - 1.82kΩ, 1%, 1/20W	Mepco	RNC50H 1821FR	MIL-R-55182	Established Reliability	Q		1	1	1	1						4
	R11	RESISTOR - 1.78kΩ, 1%, 1/20W	Mepco	RNC50H 1781FR		Established Reliability	Q		1									1
	R14	RESISTOR - 725kΩ, 1%, 3/4W	Caddock	MK132	MIL-R-55182	Established Reliability	Q		1	1	1	1						4

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER
NAMESEC39106625
ELECTRON-PROTON SPECTROMETERNEXT ASSEMBLY: NUMBER
NAMESEC39106675
DISCRIMINATOR SLICE

ASSEMBLY:

NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

QUANTITY PER SUB ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SUB ASSEMBLY NUMBER										TOTAL REQUIRED PER ASSEMBLY
								SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305						
	R14	RESISTOR - 750k Ω , 1%, 3/4W	Caddock	MK132	MIL-R-55182	Hi-Rel Testing	Q	1										1
	R15, R16	RESISTOR - 169 Ω , 1%, 1/20W	Mepco	RNC50H 1690FR	"	Established Reliability	Q	2	2	2	2	2						10
	R17	RESISTOR - 1.0k Ω , 1%, 1/20W	"	RNC50H 1001FR	"		Q	1	1	1	1	1						5
	R18, R19	RESISTOR - 100 Ω , 1%, 1/20W	"	RNC50H 1000FR	"		Q	2	2	2	2	2						10
	R20, R21, R22	RESISTOR - 49.9k Ω , 1%, 1/20W	"	RNC50H 4992FR	"		Q	3	3	3	3	3						15
	R23, R24																	
	R29, R30	RESISTOR - 33.2 Ω , 1%, 1/20W	"	RNC50K 33R2FR	"		Q	4	4	4	4	4						20
	R26, R27	RESISTOR - 100k Ω , 1%, 1/20W	"	RNC50H 1003FR	"		Q	2	2	2	2	2						10
	R28	RESISTOR - 4.02k Ω , 1%, 1/20W	"	RNC50H 4021FR	"	Established Reliability	Q	1	1	1	1	1						5
	R31	POTENTIOMETER - 100k Ω , 5%	Bourns	3262WM 39104	MIL-R-22097	Hi-Rel Testing	Q	1	1	1	1	1						5
	R32	RESISTOR - 36.5k Ω , 1%, 1/20W	Mepco	RNC50H 3652FR	MIL-R-55182	Established Reliability	Q	1	1	1	1	1						5
	R33	RESISTOR - 158k Ω , 1%, 1/20W	"	RNC50H 1583FR	"	Established Reliability	Q	1	1	1	1	1						5
	R34	RESISTOR - 30.1k Ω , 1%, 1/20W	"	RNC50H 3012FR	"	Established Reliability	Q	1	1	1	1	1						5
	R35	RESISTOR - 97.6 Ω , 1%, 1/20W	"	RNC50H 97R6FR	"	Established Reliability	Q	1	1	1	1	1						5
	R36	POTENTIOMETER - 10k, 5%	Bourns	3260HM 39103	MIL-R-22097	Hi-Rel Testing	Q	1	1	1	1	1						5

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY						TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	SEC39106664-301	SEC39106664-302	SEC39106664-303	SEC39106664-304	SEC39106664-305	
	C1 thru C7	CAPACITOR - 1 μ f, 10%, 100V	Kemet	CKR06 BX104KR	MIL-C-19014	Established Reliability	Q	7	7	7	7	7		35
	C8, C9	CAPACITOR - 220pf, 10%, 200V	Kemet	CKR05 BX221KR	"	Established Reliability	Q	2	2	2	2	2		10
	C10	CAPACITOR - 68 μ f, 10%, 15V	"	T210C68 6K015RS	MIL-C-39003		Q	1	1	1	1	1		5
	C11, C12, C14, C15	CAPACITOR - .01 μ f, 10%, 200V	"	CKR06 BX103KP	MIL-C-19014		Q	4	4	4	4	4		20
	C13, C18	CAPACITOR - 100pf, 10%, 200V	"	CKR05 BX101KP	"		Q	2	2	2	2	2		10
	C17	CAPACITOR - 2.2 μ f, 10%, 20V	"	T210A225 K020RS	MIL-C-39003	Established Reliability	Q	1	1	1	1	1		5
	L1 thru L4	INDUCTOR - 100 μ H	J. W. Miller	9210-76	MIL-C-15305	J. W. Miller Hi-Rel Spec	Q	4	4	4	4	4		20
	Z6	AMPLIFIER	Advance Micro	LM108/883	MIL-STD 883-Level A	Established Reliability	Q	1	1	1	1	1		5
	CR1, CR2	DIODE - Silicon, Switching	Texas Instruments	JAN-TX 1N914	MIL-S-19500/116	JAN-TX Hi-Rel	Q	2	2	2	2	2		10
	CR3, CR4	DIODE - Silicon Hot Carrier	Hewlett Packard	SN5473T	MIL-S-19500	Hi-Rel Special Test	Q	1	1	1	1	1		5
	Z1, Z2	AMPLIFIER	Signetix	SE526K	MIL-STD 883/Level A	Established Reliability	Q	2	2	2	2	2		10
	Z3	JK Flip-Flop	Texas Instruments	SN5473S	MIL-STD 883/Level A	Established Reliability	Q	1	1	1	1	1		5
	Z4, Z5	AMPLIFIER	Harris Semiconductor	HA-2-2520-2	MIL-STD 883/Level A	Established Reliability	Q	2	2	2	2	2		10
	P3, P4	CONNECTOR - PCB Receptacle	Microdot	031-0070-001	MIL-C-38300A	Hi-Rel Testing	Q	2	2	2	2	2		10
	S2	CONNECTOR - Screw Mount	Microdot	MCDM1-15341A-.5	MIL-C-38300A	Hi-Rel Testing	Q	1	1	1	1	1		5
	P1	CONNECTOR - Screw Mount	Microdot	MCDM1-21041A-.5	MIL-C-38300A	Hi-Rel Testing	Q	1	1	1	1	1		5

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SKYLAB ELECTRON-PROTON SPECTROMETER

EEE PARTS LIST

REVISION A (UPDATE)

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER

NEXT ASSEMBLY: NUMBER SEC39106675
 NAME DISCRIMINATOR SLICE

ASSEMBLY:
 NUMBER SEC39106664
 NAME PULSE HEIGHT DISCRIMINATOR

QUANTITY PER SUB ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	FROM -301 to -306	FROM -302 to -306	FROM -303 to -306	FROM -304 to -306	FROM -305 to -306					
	R-5	RESISTOR - 750 Ω , 1 $\%$	Mepco	RNC50H 7500FR	MIL-R-55182	Established Reliability	Q	1										
		Changed to 1.18k, 1 $\%$	Mepco	RNC50H 1181FR	MIL-R-55182	Established Reliability	Q	1										
	R7	RESISTOR - 464 Ω , 1 $\%$	Mepco	RNC50H 4640FR	MIL-R-55182	Established Reliability	Q											
		Changed to 69.8 Ω , 1 $\%$	Mepco	RNC50H 69R8FR	MIL-R-55182	Established Reliability	Q	1										
	R4	RESISTOR - 500k, 1 $\%$	Caddock	MK132-500k	MIL-R-55182	Hi-Rel Testing	Q											
		Changed to 100k, 1 $\%$	Caddock	MK132-100k	MIL-R-55182	Hi-Rel Testing	Q	1										
	R3	RESISTOR - 1.47k, 1 $\%$	Mepco	RNC50H 1471FR	MIL-R-55182	Established Reliability	Q											
		Changed to 1.54k, 1 $\%$	Mepco	RNC50H 1541FR	MIL-R-55182	Established Reliability	Q	1										
	R5	RESISTOR - 715 Ω , 1 $\%$	Mepco	RNC50H 7150FR	MIL-R-55182	Established Reliability	Q											
		Changed to 1.18k, 1 $\%$	Mepco	RNC50H 1181FR	MIL-R-55182	Established Reliability	Q	1										
	R7	RESISTOR - 604 Ω , 1 $\%$	Mepco	RNC50H 6040FR	MIL-R-55182	Established Reliability	Q											
		Changed to 69.8 Ω	Mepco	RNC50H 69R8FR	MIL-R-55182	Established Reliability	Q	1										
	R4	RESISTOR - 440k, 1 $\%$	Caddock	MK132-440k	MIL-R-55182	Hi-Rel Testing	Q											
		Changed to 100k, 1 $\%$	Caddock	MK132-100k	MIL-R-55182	Hi-Rel Testing	Q	1										

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SKYLAB ELECTRON-PROTON SPECTROMETER

EEE PARTS LIST REVISION A (UPDATE)

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106675
 NAME DISCRIMINATOR SLICE

ASSEMBLY: NUMBER SEC39106664
 NAME PULSE HEIGHT DISCRIMINATOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								From -301 to -306	From -302 to -306	From -303 to -306	From -304 to -306	From -305 to -306						
	R3	RESISTOR - 1.50k, 1%	Mepco	RNC50H 1501FR	MIL-R-55182	Established Reliability	Q											
		Changed to 1.54k, 1%	Mepco	RNC50H 1541	MIL-R-55182	Established Reliability	Q		1									
	R5	RESISTOR - 787Ω, 1%	Mepco	RNC50H 7870FR	MIL-R-55182	Established Reliability	Q											
		Changed to 1.18k, 1%	Mepco	RNC50H 1181FR	MIL-R-55182	Established Reliability	Q		1									
	R7	RESISTOR - 487Ω, 1%	Mepco	RNC50H 4870FR	MIL-R-55182	Established Reliability	Q											
		Changed to 69.8Ω, 1%	Mepco	RNC50H 69R8FR	MIL-R-55182	Established Reliability	Q		1									
	R4.	RESISTOR - 480k, 1%	Caddock	MK132-480k	MIL-R-55182	Hi-Rel Testing												
		Changed to 100k, 1%	Caddock	MK132-100k	MIL-R-55182	Hi-Rel Testing			1									
	R5	RESISTOR - 1.00k, 1%	Mepco	RNC50H 1001FR	MIL-R-55182	Established Reliability												
		Changed to 1.18k, 1%	Mepco	RNC50H 1181FR	MIL-R-55182	Established Reliability				1								
	R7	RESISTOR - 294Ω, 1%	Mepco	RNC50H 2940FR	MIL-R-55182	Established Reliability												
		Changed to 69.8Ω, 1%	Mepco	RNC50H 69R8FR	MIL-R-55182	Established Reliability				1								
	R4	RESISTOR - 550k, 1%	Caddock	MK132-550k	MIL-R-55182	Established Reliability												
		Changed to 100k, 1%	Caddock	MK132-100k	MIL-R-55182	Established Reliability				1								
	R5	RESISTOR - 1.13k, 1%	Mepco	RNC50H 1131FR	MIL-R-55182	Established Reliability												
		Changed to 1.10k, 1%	Mepco	RNC50H 1101FR	MIL-R-55182	Established Reliability						1						

TOP ASSEMBLY: NUMBER	SEC39106425
NAME	ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER	SEC39106675
NAME	DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106664
NAME PULSE HEIGHT DISCRIMINATOR

[illegible]

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS											TOTAL PER		
				PART NO. OR DRAWING NO.				From -30	From -30	From -30	From -30	From -30	From -30	From -30	From -30	From -30	From -30			
1	R7	RESISTOR - 267Ω, 1%	Mepco	RNC50H 2670FR	MIL-R- 55182	Established Reliability														
		Changed to 69.8Ω, 1%	Mepco	RNC50H 69R8FR	MIL-R- 55182	Established Reliability							1							
	R4	RESISTOR - 580k, 1%	Caddock	MK132- 580k	MIL-R- 55182	Hi-Rel Testing														
		Changed to 100k, 1%	Caddock	MK132- 100k	MIL-R- 55182	Hi-Rel Testing							1							
	R6	POTENTIOMETER - 100Ω, 1%	Bourns	3260HM 39101	MIL-R- 22097	Hi-Rel Testing														
		Changed to 200Ω, 1%	Bourns	3260HM 39201	MIL-R- 22097	Hi-Rel Testing								1						

REVISION A (UPDATE)

SEC39106425

ELECTRON-PROTON SPECTROMETER

SEC39106695

DISCRIMINATOR SLICE

NUMBER SEC39106664

NAME DETECTOR RESOLUTION MONITOR

QUANTITY PER SUB ASSEMBLY

REVISION LETTER _____

PAGE ____ OF ____

SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106675
 NAME DISCRIMINATOR SLICE



ASSEMBLY:
 NUMBER SEC39106669
 NAME HEATER CONTROL

QUANTITY PER SUB ASSEMBLY

SUB
ASSEMBLY
NUMBER

SEC39106669-301

TOTAL REQUIRED
PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	R1	RESISTOR - 13k Ω , 1%, 1/20W	Mepco	RNC50H 1372FR	MIL-R-55182	Established Reliability	Q 1											1
	R2	RESISTOR - 33 Ω , 5%, 1/4W	Allen Bradley	RCR07G 330JP	MIL-R-39008		Q 1											1
	R3	RESISTOR - 19.1k Ω , 1%, 1/20W	Mepco	RNC50H 1912FR	MIL-R-55182		Q 1											1
	R4	RESISTOR - 47.5k Ω , 1%, 1/20W	"	RNC50H 4752FR	"		Q 1											1
	R5	RESISTOR - 45.3k Ω , 1%, 1/20W	"	RNC50H 4532FR	"		Q 1											1
	R6	RESISTOR - 49.9k Ω , 1%, 1/20W	"	RNC50H 4992FR	"		Q 1											1
	R8	RESISTOR - 4.99k Ω , 1%, 1/20W	"	RNC50H 4991FR	"		Q 1											1
	R9	RESISTOR - 66 Ω , 1%, 1/20W	"	RNC50H 6650FR	"		Q 1											1
	R10	RESISTOR - 619 Ω , 1%, 1/20W	"	RNC50H 6190FR	"		Q 1											1
	R11	RESISTOR - 1.91k Ω , 1%, 1/20W	"	RNC50H 1911FR	"		Q 1											1
	R12	RESISTOR - 2.61k Ω , 1%, 1/20W	"	RNC50H 2611FR	"		Q 1											1
	R13	RESISTOR - 10k Ω , 1%, 1/20W	"	RNC50H 1002FR	"		Q 1											1
	R14	RESISTOR - 7.68k Ω , 1%, 1/20W	"	RNC50H 7681FR	"		Q 1											1
	R15	RESISTOR - 3.0k Ω , 1%, 1/20W	"	RCR07G 302JS	MIL-R-39008		Q 1											1
	R16	RESISTOR - 100k Ω , 5%, 1/4W	Allen Bradley	RCR07G 104JR	"	 Established Reliability	Q 1											1

REVISION LETTER _____

PAGE ____ OF ____

SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106675
NAME DISCRIMINATOR SLICE

ASSEMBLY:
NUMBER SEC39106669
NAME HEATER CONTROL

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								Sub Assembly Number										
	R17	RESISTOR - 4.99k Ω , 1%, 1/20W.	Mepco	RNC50H 4991FR	MIL-R-55182	Established Reliability	Q	1										1
	R18	RESISTOR - 20.0k Ω , 1%, 1/20W	"	RNC50H 2002FR	"		Q	1										1
	R19	RESISTOR - 2.2M Ω , 5%, 1/4W	Allen Bradley	RCR07G 225JR	MIL-R-39008		Q	1										1
	R20	RESISTOR - 1.2M Ω , 5%, 1/4W	"	RCR07G 125JR	"		Q	1										1
	R21	RESISTOR - 100k Ω , 5%, 1/4W	"	RCR07G 104JR	"		Q	1										1
	C1	CAPACITOR - 100pF, 10%, 200V	Kemet	CKR05 BX101KR	MIL-C-39014		Q	1										1
	C2	CAPACITOR - 10 μ F, 10%, 75V	"	CSR13G 186KR	MIL-C-39003		Q	1										1
	Q1, Q2	TRANSISTOR - NPN, Amplifier	Teledyne	JAN-TX 2N2484	MIL-S- 19500/376		Q	2										2
	Q3, Q4	TRANSISTOR - NPN, Power	Texas Instruments	JAN-TX 3421	MIL-S- 19500/393	Established Reliability	Q	2										2
	Q5	TRANSISTOR - FET, Silicon	Texas Instrument	JAN 2N2609	MIL-S- 19500/296	LEC Spec #214	Q	1										1
	A1	AMPLIFIER	Advance Micro	uA723 1883	MIL-STD- 883/Level A	Established Reliability	Q	1										1
	CR1	DIODE - Switching, Silicon	Texas Instruments	JAN-TX 1N914	MIL-S- 19500/116	Established Reliability	Q	1										1

REVISION LETTER _____

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SKYLAB ELECTRON-PROTON SPECTROMETER

EEE PARTS LIST REVISION A (UPDATE)

TOP ASSEMBLY: NUMBER
NAME
NEXT ASSEMBLY: NUMBER
NAME

SEC39106425
ELECTRON-PROTON SPECTROMETER
N/A

ASSEMBLY:
NUMBER
NAME

N/A

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS											
		FILM HEATER	Electro Film	112558-1	Manuf. Specification	LEC EPS Specification	Q											

REVISION LETTER _____

SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

PAGE _____ OF _____

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106690
NAME DATA PROCESSOR LVPS SLICE

ASSEMBLY:
NUMBER SEC39106980
NAME LOW VOLTAGE PWR SUPPLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	SEC39106980-301									
	FL4	FILTER	Potter	8332-126	MIL-C-15305	Hi-Rel Testing	Q	1										1
	FL2, FL3, FL5 - FL8	FILTER	Potter	8332-125	MIL-C-15305	Hi-Rel Testing	Q	6										6
	Q3	TRANSISTOR	Motorola	2N5333	MIL-S-19500	LEC Spec EPS-179	Q	1										1
	C20, C21	CAPACITOR - 15pf, 75V	Kemet	T210P156K 075PS	MIL-C-39014	Established Reliability	Q	2										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106980
NAME LOW VOLTAGE POWER SUPPLY

ASSEMBLY:
NUMBER SEC39106671
NAME PRIMARY SIDE

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39106671-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS										
	CR1, CR12-CR15 CR17-CR20	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Testing	Q	9									9

REVISION LETTER _____

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106671
NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106676
NAME PREREGULATOR MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	R1	RESISTOR - 33.2k Ω , 1%, 1/10W	Mepco	RNC55H-3322FR	MIL-R-55182	Established Reliability	Q	1										1
	R2A, R2B	RESISTOR - 3.9k Ω , 5%, 1/2W	Allen Bradley	RCR20G 392SP	MIL-R-39008	<div style="text-align: center;"> \uparrow Established Reliability \downarrow </div>	Q	2										2
	R3	RESISTOR - 4.75k Ω , 1%, 1/10W	Mepco	RNC55H 4751FR	MIL-R-55182		Q	1										1
	R4	RESISTOR - 100 Ω , 5%, 1/4W	Allen Bradley	RCR07G 101JP	MIL-R-39008		Q	1										1
	R5	RESISTOR - 10 Ω , 5%, 1/4W	Allen Bradley	RCR07G 100JP	MIL-R-39008		Q	1										1
	R6	RESISTOR - 39.2k Ω , 1%, 1/20W	Mepco	RNC50H 3922FR	MIL-R-55182		Q	1										1
	R7	RESISTOR - 5.62k Ω , 1%, 1/10W	Mepco	RNC50H 5621FR	"		Q	1										1
	R8, R9	RESISTOR - 2.21k Ω , 1%, 1/20W	Mepco	RNC50H 2211FR	"		Q	2										2
	R10	RESISTOR - 18.2k Ω , 1%, 1/20W	Mepco	RNC50H 1822FR	"		Q	1										1
	R11	RESISTOR - To Be Determined	Mepco	RNC50H	"		Q	1										1
	R12	RESISTOR - To Be Determined	Mepco	RNC50H	"		Q	1										1
	C1, C8	CAPACITOR - 22 μ f	Kemet	T210D226 K050PS	MIL-C-39003		Q	2										2
	C2	CAPACITOR - 3300pf	Kemet	CKR06 BX332KP	MIL-C-39014		Q	1										1
	Q1	TRANSISTOR	Texas Instruments	JAN TX 2N2222A	MIL-S-19500	<div style="text-align: center;"> \downarrow Established Reliability \downarrow </div>	Q	1										1
	Q2	TRANSISTOR	Texas Instruments	JAN TX 2N3421	"		Q	1										1
	Q4	TRANSISTOR	Texas Instruments	JAN TX 2N444A	"		Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER
NAME
NEXT ASSEMBLY: NUMBER
NAME

SEC39106425
ELECTRON-PROTON SPECTROMETER
SEC39106671
PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106676
NAME PREREGULATOR MODULE

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39106676-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SFC391											TOTAL PER 4
	Q5, Q6	TRANSISTOR	Texas Instruments	JAN TX 2N2907A	MIL-S-19500	Established Reliability	Q	2											2
	Q7	TRANSISTOR	Teledyne	JAN TX 2N2484	MIL-S-19500	Established Reliability	Q	1											1
	CR1	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Spec. Tests	Q	1											1
	CR2, CR3 CR5, CR6	DIODE	Texas Instruments	JAN TX 1N914	MIL-S-19500	Established Reliability	Q	4											4
	CR4	DIODE - Zener	Dickson	1N4567A	MIL-S-19500	Hi-Rel Spec. Tests	Q	1											1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106671
 NAME PRIMARY SIDE

ASSEMBLY:
 NUMBER SEC39106677
 NAME CORE DRIVER MODULE

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
SEC39106677-301											

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	R14	RESISTOR - 4.7k Ω , 5%, 1/4W	Dale	RCR07G 472JP	MIL-R-39008	Established Reliability	Q	1											1
	R15	RESISTOR - 100 Ω , 5%, 1/4W	Dale	RCR07G 101JP	MIL-R-39008		Q	1											1
	R16	RESISTOR - 47 Ω , 5%, 1/4W	Dale	RCR07G 470JP	MIL-R-39008		Q	1											1
	R17	RESISTOR - 28k Ω , 1%, 1/20W	Mepco	RNC50H 283FR	MIL-R-55182		Q	1											1
	R38	RESISTOR - 10k Ω , 1%, 1/20W	Mepco	RNC50H 103FR	"		Q	1											1
	C3	CAPACITOR - 22 μ f, 50V	Kemet	T210D226 K050PS	MIL-C-39003		Q	1											1
	C4	CAPACITOR - 4.7 μ f, 10V	Kemet	T210A475 K010RS	"		Q	1											1
	CR7	DIODE	Texas Instruments	JAN-TX- 1N746A	MIL-S-19500		Q	1											1
	CR8, CR9	DIODE	Texas Instruments	JAN-TX- 1N914	"		Q	2											2
	CR10	DIODE	Texas Instruments	JAN-TX- 1N645	"		Q	2											2
	Q8, Q9 Q10	TRANSISTOR	Texas Instruments	JAN-TX- 2N3421	"		Q	3											3
	Q11	TRANSISTOR	Texas Instruments	JAN-TX- 2N2484	"	Established Reliability	Q	1											1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106671
NAME PRIMARY SIDE

ASSEMBLY:
NUMBER SEC39106678
NAME RECTIFIER-FILTER MODULE

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39106678-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	C7, C10	CAPACITOR - 47µf, 20V	Kemet	T210C476 K020RS	MIL-C-39008	Established Reliability	Q	2											2
	C16, C18	CAPACITOR - 3.9µf, 75V	Kemet	T210B395 K075PS	"	Established Reliability	Q	2											2
	C12, C14	CAPACITOR - 68µf, 15V	Kemet	T210CG86 K015RS	"	Established Reliability	Q	2											2
	CR22, CR23	DIODE	Texas Instruments	JAN TX 1N645	MIL-S-19500	Established Reliability	Q	2											2

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106980
 NAME LOW VOLTAGE POWER SUPPLY

ASSEMBLY:
 NUMBER SEC39106672
 NAME SECONDARY SIDE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	R19	POTENTIOMETER - 10k	Bourns	3262W-1-103	MIL-R-27208	Hi-Rel Testing	Q	1										1
	Z1	VOLTAGE REGULATOR	Fairchild	u723	MIL-STD-883/Level A	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER
NAMESEC39106425
ELECTRON-PROTON SPECTROMETER

ASSEMBLY:

NUMBER SEC39106688

NEXT ASSEMBLY: NUMBER
NAMESEC39106672
SECONDARY SIDE



NAME DISCRIMINATOR REG. MODULE

QUANTITY PER SUB ASSEMBLY

SUB
ASSEMBLY
NUMBER

SEC39106688-301

TOTAL REQUIRED
PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	R18	RESISTOR - 11.5k Ω , 1%, 1/20W	Mepco	RNC50H 1152FR	MIL-R-55182	Established Reliability	Q	1										1
	R20, R22	RESISTOR - 5.98k Ω , 1%, 1/20W	Mepco	RNC50H 6981FR	"		Q	2										2
	R21	RESISTOR - 13 Ω , 5%, 1/4W	Allen Bradley	RCR07G 130JP	MIL-R-39008		Q	1										1
	R39	RESISTOR - 15k Ω , 1%, 1/20W	Mepco	RNC50H 153FR	MIL-R-55182		Q	1										1
	C5	CAPACITOR - 1000pf, 200V	Kemet	CKR05BX 102KP	MIL-C-39014		Q	1										1
	C6	CAPACITOR - 100pf, 200V	Kemet	CKR05BX 101KP	MIL-C-39014		Q	1										1
	C9, C11	CAPACITOR - 15 μ f, 20V	Kemet	T210B156 K020RS	MIL-C-39003		Q	2										2
	C13, C15	CAPACITOR - 22 μ f, 15V	Kemet	T210B226 K015RS	"		Q	2										2
	C17, C19	CAPACITOR - 3.9 μ f, 75V	Kemet	T210B395 K075PS	"		Q	2										2
	CR24	DIODE - Zener	Texas Instruments	JAN TX 1N758A	MIL-S-19500	Established Reliability	Q	1										1

REVISION LETTER _____

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106690
NAME DATA PROCESSOR LVPS SLICE

ASSEMBLY :
NUMBER SEC39107473
NAME INPUT FILTER MODULE

QUAL. STATUS		SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY	TOTAL REQUIRED PER ASSEMBLY
		SEC39107473-301		

[illegible]

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39107473
NAME INPUT FILTER MODULE

ASSEMBLY:
NUMBER SEC39107014
NAME INPUT FILTER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107014-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	R3	RESISTOR - 2.7Ω, 1%, 1/8W	Allen Bradley	PCR05G 2R7JS	MIL-R-39008	Established Reliability	Q	1											1
	C1, C3 - C6	CAPACITOR - 15pf, 75V	Kemet	T210D156 K075PS	MIL-C-39003	Established Reliability	Q	5											5
	C2, C7	CAPACITOR - .1μf, 100V	Kemet	CKR06 BX104KP	MIL-C-39014	Established Reliability	Q	2											2

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39107473
NAME INPUT FILTER MODULE

ASSEMBLY:
NUMBER SEC39107016
NAME FILTER SURGE LIMITERS

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER	SEC39107016-301									
	CR1, CR2	DIODE	Unitrode	1N4942	MIL-S-19500	Hi-Rel Testing	Q	2										2
	CR3 - CR6	DIODE	Unitrode	UT4010	MIL-S-19500	Hi-Rel Testing	Q	4										4
	R1	RESISTOR - 4.7Ω, 1%, 1/8W	Allen Bradley	RCR05G 4P7JS	MIL-R-39008	Established Reliability	Q	1										1
	R2	RESISTOR - .5Ω, 1%, 1W	Dale	RWR81S R500FR	"	Established Reliability	Q	1										1
	R4	RESISTOR - 1.3Ω, 1%, 1W	Dale	RWR81S 1R300FR	"	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39106991
NAME MULTIPLEXER MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	Z1, Z2	MULTIPLEXER - 16-Channel	Harris Semi-Conductor	HS-9-1000-2	MIL-STD-883	MIL-STD-883 Level A	Q	2										2
	L1, L2	INDUCTOR - 100µH	J. W. Miller	9210-76	MIL-C-15305	Hi-Rel Testing	Q	2										2
	C1 - C2	CAPACITOR - .1µf, 100V	Union Carbide	CKR06BK 104KP	MIL-C-39014	Established Reliability	Q	2										2
	R1	RESISTOR - 1kΩ, 10%, 1/8W	Allen Bradley	RCR05G 102JS	MIL-R-39008	Established Reliability	Q	1										1
	CR1 - CR12	DIODE	Texas Instruments	JAN-TX 1N914	MIL-S-19500	Hi-Rel Testing		12										12

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106673
 NAME DATA PROCESSOR

ASSEMBLY:
 NUMBER SSEC39107003
 NAME A/D CONVERTER

QUANTITY PER SUB ASSEMBLY

SUB
ASSEMBLY
NUMBER

SEC39107003-301

TOTAL REQUIRED
PER ASSEMBLY

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SPEC391												TOTAL PER
	R3, R9, R14	RESISTOR - 4.99kΩ, 1%	Mepco	RNC50H 4992FR	MIL-R-55182	Established Reliability	Q	3												3
	R5	RESISTOR - 9.53kΩ, 1%	Mepco	RNC50H 9532FR	"	Established Reliability	Q	1												1
	R8	RESISTOR - Selected	Mepco	RNC50H	"	Established Reliability	Q	1												1
	R7	POTENTIOMETER - 10kΩ	Bourns	3260HM 39103	MIL-R-27208	Hi-Rel Testing	Q	1												1
	R4	RESISTOR - 11.3kΩ, 1%	Mepco	RNC50H 1132FR	MIL-R-55182	Established Reliability	Q	1												1
	R2, R10	RESISTOR - 10MΩ, 1%	Caddock	MG660	MIL-R-55182	Hi-Rel Testing	Q	2												2
	R6	RESISTOR - 47.5kΩ, 1%	Mepco	RNC50H 4752FR	"	Established Reliability	Q	1												1
	R11, R12, R13	RESISTOR - 49.9kΩ, 1%	Mepco	49922FR	"	Established Reliability	Q	3												3
	Z1 thru Z3	INTEGRATED CIRCUIT	Advance Micro	LM108/883	MIL-STD-883/Level A	Hi-Rel Testing	Q	3												3
	Z4	INTEGRATED CIRCUIT	Advance Micro	LM 111/883/Level A	MIL-STD-883/Level A	Hi-Rel Testing	Q	1												1
	Z5	INTEGRATED CIRCUIT	Dickson	DAS2132	MIL-STD-883/Level A	Hi-Rel Testing	Q	1												1
	VR1	DIODE - Zener	Dickson	1N4567A	MIL-S-19500	Hi-Rel Testing	Q	1												1
	CR2, CR3	DIODE	Texas Instruments	JANTX 1N914	"	Established TX Testing	Q	2												2
	L1, L2	INDUCTOR	Miller	MS90538-12	MIL-C-15305	Hi-Rel Testing	Q	2												2
	C15	CAPACITOR - 2μf	TRW	X483G	MIL-C-39014	Established Reliability	Q	1												1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY: NUMBER SEC39107003
NAME A/D CONVERTER

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107003-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS										
	C3, C4, C6, C7, C9, C10 C11, C13, C14	CAPACITOR - .1uf	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q 9										9
	C12	CAPACITOR - .01uf	Kemet	CKR06BX 103KP	MIL-C-39014	Established Reliability	Q 1										1
	C5, C8, C16	CAPACITOR - 100pf	Kemet	CKR05BX 101KP	MIL-C-39014	Established Reliability	Q 3										3

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107005
NAME A/D LOGIC MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
5	21, 26, 28, 216	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 01-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	4										4
	22, 27, 29	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H	▲	Q	3										3
	23, 213, 215, 218	" "	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level H		Q	4										4
	24, 214	" "	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level H		Q	2										2
	25	" "	Advance Micro	U4296L 0251	MIL-STD-883 Level H		Q	1										1
	210	" "	Texas Instruments	SNH54L 30T-02	MIL-STD-883 Level H		Q	1										1
	211	" "	Texas Instruments	SNH54L 20T-02	MIL-STD-883 Level H		Q	1										1
	212, 217	" "	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H	▼	Q	2										2
	R1	RESISTOR - 22kΩ, 1%, 1/20W	Mepco	RNC50H 2202FR	MIL-R-55182	Established Reliability	Q	1										1
	R2, R4	RESISTOR - 1.0kΩ, 1%, 1/20W	"	RNC50H 1001FR	"	▲	Q	2										2
	R3	RESISTOR - 10kΩ, 1%, 1/20W	"	RNC50H 1002FR	"		Q	1										1
	C1	CAPACITOR - 100pF	USCC	RC10G 101J	MIL-C-39014		Q	1										1
	C2	CAPACITOR - .1μF	Kemet	CKR06BX 104KP	"		Q	1										1
	C3	CAPACITOR - 3.3μF	Kemet	T210A335 K015R3	MIL-C-39003	Established Reliability	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY: NUMBER SEC39106992
NAME VOLTAGE MONITOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39106992-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	R14	RESISTOR - 100kΩ, 1%	Mepco	RNC50H 1003FR	MIL-R-55182	Established Reliability	Q	1											1
	R12, R13	RESISTOR - 5.11kΩ, 1%	"	RNC50H 5111FR	"	↑	Q	2											2
	R10, R11	RESISTOR - 8.66kΩ, 1%	"	RNC50H 8661FR	"		Q	2											2
	R9	RESISTOR - 24.9kΩ, 1%	"	RNC50H 2492FR	"		Q	1											1
	R8	RESISTOR - 4.99kΩ, 1%	"	RNC50H 4991FR	"		Q	1											1
	R7	RESISTOR - 16.2kΩ, 1%	"	RNC50H 1622FR	"		Q	1											1
	R5	RESISTOR - 78.7kΩ, 1%	"	RNC50H 7872FR	"		Q	1											1
	R4	RESISTOR - 21.5kΩ, 1%	"	RNC50H 2152FR	"		Q	1											1
	R3	RESISTOR - 22.1kΩ, 1%	"	RNC50H 2212FR	"	↓	Q	1											1
	R2, R6, R15	RESISTOR - 10.0kΩ, 1%	"	RNC50H 1002FR	"	Established Reliability	Q	3											3
	CR1, CR2, CR3	DIODE	Texas Instruments	JANTX 1N914		Established Reliability	Q	3											3

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106673
 NAME DATA PROCESSOR

ASSEMBLY:
 NUMBER SEC39106994
 NAME COUNTER CONTROL

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	Z1	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1										1
	22, 25, 26, 29, 210, 213	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	6										6
	23, 24, 27, 28, 211, 212	" "	Texas Instruments	SNH54L 95T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	6										6
	214	" "	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1										1
	C1	CAPACITOR - 0.1 μ f	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1										1
	C2	CAPACITOR - 3.3 μ f, 15V	Kemet	T210A335 K015RS	MIL-C-39003	Established Reliability	Q	1										1
	R1	RESISTOR - 4.99k Ω , 1%	Mepco	RNC50H 4991FR	MIL-R-55182		Q	1										1
	R2	RESISTOR - 10k Ω , 1%	Allen Bradley	RCR05G 102JS	MIL-R-39008		Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY: NUMBER SEC39106997
NAME SEQUENCER MODULE

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39106997-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS												
	24, 216, 217, 220, 222	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	5											5
	27, 213	"	Texas Instruments	SNH54L 20T-02	MIL-STD-883 Level H	↑	Q	2											2
	23, 224, 225	"	Texas Instruments	SNH54L 10T-02	MIL-STD-883 Level H		Q	3											3
	22, 214, 218, 221	"	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H		Q	4											4
	25, 215, 219, 223	"	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level H		Q	4											4
	21	"	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H		Q	1											1
	26, 226	"	Advance Micro	U4L96L0251	MIL-STD-883 Level H	↓	Q	2											2
	227	"	National	LM111F	MIL-STD-883 Level H		Q	1											1
	R2, R4, R17, R19, R13, R15, R21	RESISTOR - 1k, 5%	Allen Bradley	RCR05G 102JS	MIL-R-39008	Established Reliability	Q	7											7
	R5, R6, R7, R20	RESISTOR - 10kΩ, 5%	Allen Bradley	RCR05G 103JS	"	↑	Q	4											4
	R1, R14, R16	RESISTOR - 22kΩ, 5%	Allen Bradley	RCR05G 223JS	"		Q	3											3
	R8	RESISTOR - 100Ω, 1%, 1/20W	Mepco	RNC50H 1000FR	MIL-R-55182		Q	1											1
	R12	RESISTOR - 2.94kΩ, 1%, 1/20W	Mepco	RNC50H 2941FR	MIL-R-55182	Established Reliability	Q	1											1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106673
 NAME DATA PROCESSOR

ASSEMBLY:
 NUMBER SEC39106997
 NAME SEQUENCER MODULE

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	R11	RESISTOR - 6.04k Ω , 1 $\%$, 1/20W	Mepco	RNC50H 6041FR	MIL-R-55182	Established Reliability	Q	1										1
	R9	RESISTOR - 10.5k Ω , 1 $\%$, 1/20W	Mepco	RNC50H 1052FR	"	Established Reliability	Q	1										1
	R10	RESISTOR - 51.1k Ω , 1 $\%$, 1/20W	Mepco	RNC50H 5112FR	"	Established Reliability	Q	1										1
	C1, C2, C3	CAPACITOR - 100pf, 50V	USCC	RC10C101J	MIL-C-39014	Hi-Rel Vendor Test	Q	3										3
	C5	CAPACITOR - 3.3pf, 15V	Kemet	T210335 K015RS	MIL-C-39003	Established Reliability	Q	1										1
	C4	CAPACITOR - 0.1pf, 100V	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1										1
	CR1	DIODE	Hewlett Packard	HP5082-2827	MIL-S-19500	Hi-Rel Vendor Test	Q	1										1

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
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NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY:
NUMBER SEC39107000
NAME COMPRESSOR

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
								SUB ASSEMBLY NUMBER										
	Q1, Q2 Q3	TRANSISTOR	Texas Instruments	JANTX 2N222	MIL-S-19500	Hi-Rel JANTX Test	Q	3										3
	C1	CAPACITOR - 6800 pf, 50V	USCC	RC10C 682J	MIL-C-39014	Hi-Rel Testing	Q	1										1
	C2, C3, C4, C5	CAPACITOR - 100pf, 50V	USCC	RC10C 101J	MIL-C-39014	Hi-Rel Testing	Q	4										4
	C6	CAPACITOR - 0.1uf, 100V	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q	1										1
	C7	CAPACITOR - 3.3uf, 15V	Kemet	T210A335 K015RS	MIL-C-39003	▲	Q	1										1
	R1	RESISTOR - 5.62kΩ, 1%	Mepco	RNC50H 5621FR	MIL-R-55182		Q	1										1
	R2, R3	RESISTOR - 4.99kΩ, 1%	Mepco	RNC50H 4991FR	"		Q	1										1
	R4	RESISTOR - 1.13kΩ, 1%	Mepco	RNC50H 1131FR	"		Q	2										2
	R5, R20 R21, R22	RESISTOR - 10kΩ, 5%	Allen Bradley	RCR05G 103JS	"		Q	1										1
	R23	RESISTOR - 18kΩ, 5%	Allen Bradley	RCR05G 183JS	"		Q	4										4
	R6, R9, R11, R13	RESISTOR - 22kΩ, 5%	Allen Bradley	RCR05G 223JS	"		Q	1										1
	R14, R19, R7, R8, R9, R10, R12, R24, R25	RESISTOR - 1.0kΩ, 5%	Allen Bradley	RCR05G 102JS	"	▼ Established Reliability	Q	13										13

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
NAME ELECTRON-PROTON SPECTROMETER
NEXT ASSEMBLY: NUMBER SEC39106673
NAME DATA PROCESSOR

ASSEMBLY: NUMBER SEC39107000
NAME COMPRESSOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
	SEC39107000-301										

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL. STATUS	SNC3910												TOTAL
	21, 222,	INTEGRATED CIRCUIT	Advance Micro	U4L96L 0251	MIL-STD-883 Level A	Hi-Rel Testing	Q	2										2		
	210	" "	Texas Instruments	SNH54L 93T-02	MIL-STD-883 Level H	↑	Q	1										1		
	22, 24, 27, 214 216	" "	Texas Instruments	SNH54L 73T-02	MIL-STD-883 Level H		Q	5										5		
	217, 218	" "	Texas Instruments	SNH54L 30T-02	MIL-STD-883 Level H		Q	2										2		
	23, 221	" "	Texas Instruments	SNH54L 04T-02	MIL-STD-883 Level H		Q	2										2		
	28, 29, 211	" "	Texas Instruments	SNH54L 01T-02	MIL-STD-883 Level H		Q	3										3		
	213, 219, 220	" "	Texas Instruments	SNH54L 00T-02	MIL-STD-883 Level H		Q	3										3		
	212	" "	Texas Instruments	SNC54 01T-02	MIL-STD-883 Level H	Hi-Rel Testing	Q	1										1		

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SKYLAB ELECTRON-PROTON SPECTROMETER EEE PARTS LIST

TOP ASSEMBLY: NUMBER SEC39106425
 NAME ELECTRON-PROTON SPECTROMETER
 NEXT ASSEMBLY: NUMBER SEC39106673
 NAME DATA PROCESSOR

ASSEMBLY:
 NUMBER SEC39107008
 NAME WORD SYNC GENERATOR

SUB ASSEMBLY NUMBER	QUANTITY PER SUB ASSEMBLY										TOTAL REQUIRED PER ASSEMBLY
SEC39107008-301											

ITEM NO.	DRAWING DESIGNATION	DESCRIPTION AND/OR DRAWING TITLE	MFG.	MFG'S PART NO. OR DRAWING NO.	SPECIFICATION	METHOD OF QUALIFICATION	QUAL STATUS											TOTAL REQUIRED PER ASSEMBLY
	R1, R3, R5, R7, R9, R11, R13, R15, R17, R19, R21, R23, R25	RESISTOR - 510Ω, 5%	Allen Bradley	RCR05G 510JS	MIL-R-39008	Established Reliability ▲	Q 13											13
	R2, R4, R6, R8, R10, R12, R14, R16, R18, R20, R22, R24, R26	RESISTOR - 3.9kΩ, 5%	Allen Bradley	RCR05G 392JS	MIL-R-39008		Q 13											13
	R27, R28, R29, R43	RESISTOR - 1.0kΩ, 5%	Allen Bradley	RCR05G 102JS	MIL-R-39008		Q 4											4
	R42	RESISTOR - 18kΩ	Allen Bradley	RCR05G 183JS	MIL-R-39008		Q 1											1
	C1	CAPACITOR - 3.3μf	Kemet	T210A335 K015RS	MIL-C-39003		Q 1											1
	C2	CAPACITOR - .1μf	Kemet	CKR06BX 104KP	MIL-C-39014	Established Reliability	Q 1											1
	22, 24	INTEGRATED CIRCUIT	Texas Instruments	SNH54L 01T-02	MIL-STD- 883 Level H	Hi-Rel Testing	Q 2											2
	21, 23, 25	INTEGRATED CIRCUIT	Texas Instruments	SNH54 01T-02	MIL-STD- 883 Level H	Hi-Rel Testing	Q 3											3

3.3.11 Standard Parts

Refer to paragraph 3.3.10.9.1

3.3.13 Fungus Resistance

The parts and materials used on the EPS were selected to resist fungus by the elimination of nutrients which could support such fungus. The electronic assemblies are conformal coated to further prevent surface and component exposure to fungus. Humidity tests have proved that the electronics and mechanical packaging are free of nutrients for fungus. The exposed surfaces of the baseplate has been chemically treated to prevent fungus and corrosion. All other components used on the EPS are sealed or otherwise free of fungus nutrients.

3.3.13 Corrosion Prevention

Metal and mechanical parts used in the EPS are of the corrosion resistant type. Areas that are exposed to possible corrosion has been suitably treated to prevent corrosion.

3.3.14 Interchangeability and Replaceability

The EPS was designed, as a total unit, to be replaceable on any flight of Skylab. Each subassembly was designed so a like assembly will have interchangeability and replaceability. It becomes necessary to calibrate the EPS after replacement of certain modules, however, this is expected in any equipment of this type. Spare subassemblies are designed to replace those in the EPS if it becomes necessary.

3.3.18 Storage

Ancillary hardware has a storage life of five years. The only parts or materials which are sensitive to age or storage environments are the EPS detectors which are not to be installed in the EPS instrument until approximately three weeks before launch. Control is maintained on these items by historical record card.